Materials & Methods

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

Sheet Steel Shortage

Strippable Plastic Coatings

Salts for Carburizing and Cyaniding

Soldering of Zinc-Coated Parts

Hole Piercing and Stamping

Ignition of Magnesium Alloys

Submerged Melt Welding

Modern Porcelain Enamels

Low-Alloy, High-Strength Steels

MATERIALS & METHODS Manual No. 28

July 1947

PUBLISHED SINCE 1929 AS METALS AND ALLOYS

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Production Frontiers

by Harold A. Knight *News Editor*

June: For Brides and Editorial Staff Travels

Corrosion is Here to Stay

There's plenty of evidence everywhere that corrosion is here to stay—or, stated more seriously, that technical interest in corrosion problems has become a major engineering activity. The busy convolutions of the Electrochemical Society's Corrosion Div., the rapid growth of the National Association of Corrosion Engineers, and the existence of two technical magazines devoted exclusively to corrosion matters are surely all the proof anyone could wish.

A couple of us, together with several other editors, spent a few days in June watching corrosion do its darndest under close, carefully measured surveillance at the corrosion testing project operated jointly at Kure Beach, N. C. by the International Nickel Co. and the Magnesium Div., Dow Chemical Co. Here 20,000 specimens of bare and coated metals and alloys of all types are exposed under standard conditions to this highly corrosive marine atmosphere, while other samples are immersed in seawater or tested under sprays and jets. Appearance and weight changes are recorded and a frightening (at least to Frank LaQue, director of the project) mass of data of great value to industry is being thus accumulated.

Conclusions drawn from the work to date are positive verifications of what experts have long strongly suspected, while others represent brand new ideas. Thus, in its first small doses copper (up to 0.05%) is the most potent element in improving corrosion resistance of ordinary steels. The color of the rust on alloy steels is a good barometer of their resistance; dark colors indicate greater durability, and the dyed-in-the-wool corrosion expert can make a good rough appraisal of a group of steels on this basis.

With most corrosion-resistant metals and alloys corrosion proceeds most rapidly at first and then tapers off; the major changes in color and weight occur in early months, and many samples look after six years very much as they did after three months. Stainless steels, 14% plus chromium, stain rather than rust, and several grades have remarkably small amounts of staining and pitting even after seven years exposure to the salt air; types 310 (25 nickel, 20 chromium) and 316 (16 chromium, 12 nickel, 2 molybdenum) are the most resistant. Nitrided stainless steels were inferior to the un-nitrided steels.

As protective coatings for steel, aluminum varnishes and zinc dust paints seem to be the best "paints." Of the synthetic finishes, the vinyl coatings are standing up better than the phenolics. Hot-dipped aluminum coatings look promising, while galvanizing retains its position as the most economical, large-scale, long-life protective coating method for steel. The only good metal-spray coatings seem to be those of aluminum, zinc and lead.

Magnesium's surprisingly good resistance to sea-air corrosion reported in this magazine in May, 1945 have been confirmed by the 2-yr. extra testing. 56S aluminum rivets for magnesium alloy structures are now standard by virtue of their superior galvanic compatibility with the magnesium alloy, as compared with the A 17 S rivets formerly used. Cadmium-plated steel bolts used with magnesium structures give no trouble if "insulating" washers made of 52 S aluminum alloy are used. Stress-corrosion cracking of welds in magnesium alloy structures can be avoided by stress relieving treatments, and wherever possible such treatments are now standard practice for magnesium welds.

Outstanding observations as to copper alloys are (1) the evident

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replaceability of tin by nickel, in the Navy G bronze, without significant loss of either corrosion resistance or mechanical properties, and (2) cupro-nickel for condenser tubes that contains only 10% of nickel (instead of the usual 30% nickel) plus 0.8% iron is competitive in cost with aluminum brass but not subject to the latter's "dezincification," and appears to be just as good on a service basis as the traditional 70/30 cupro-nickel for condenser tubes.

The mighty *teredo,* salt-water termite that eats away pier structures and the wooden hulls of ships in harbor storage, still challenges those who would control him (or her). Poisons (*e.g.* copper-base compounds so useful for anti-fouling paints in general) merely annoy him. The most promising attack is to gum up his teeth with creosote-like goos so that he dies of discouragement.

Scores of manufacturers and institutions have samples tested on the Kure Beach racks, some of the largest projects being those of Carnegie-Illinois, Armco and the Navy Dept. The installation as a whole is an adventure in cooperation, competitors working hand-in-hand to learn more about corrosion so that all their materials will be applied in the best possible way, from the users' point of view.

Industrial Plastics to the Fore

Two trends were reported at the Annual Conference of the Society of the Plastics Industry, at Chicago in May. One was a general falling-off of orders for small molded plastics parts, best described as gadgets. It seems that Mrs. America is not demanding pastel-colored knick-knacks in the new glamour material as insistently as heretofore. One large custom molder had only two weeks' work in his shop, and many were frankly worried.

The other trend may become the beacon light pointing out a path in the gloom. This was the increasing number of inquiries about plastics for industrial use directed to exhibitors at the National Plastics Exposition, held contemporaneously.

Apparently molders must plan for a change from the production of plastics novelties, for a while at least, to parts for industry. This market means production to specifications, possibly closer dimensional tolerances, more careful selection of the type of material with regard to its use conditions, use of materials different from those formerly employed, or other changes. There are certain advantages such as less credit risk, possibilities for longer runs, and so on.

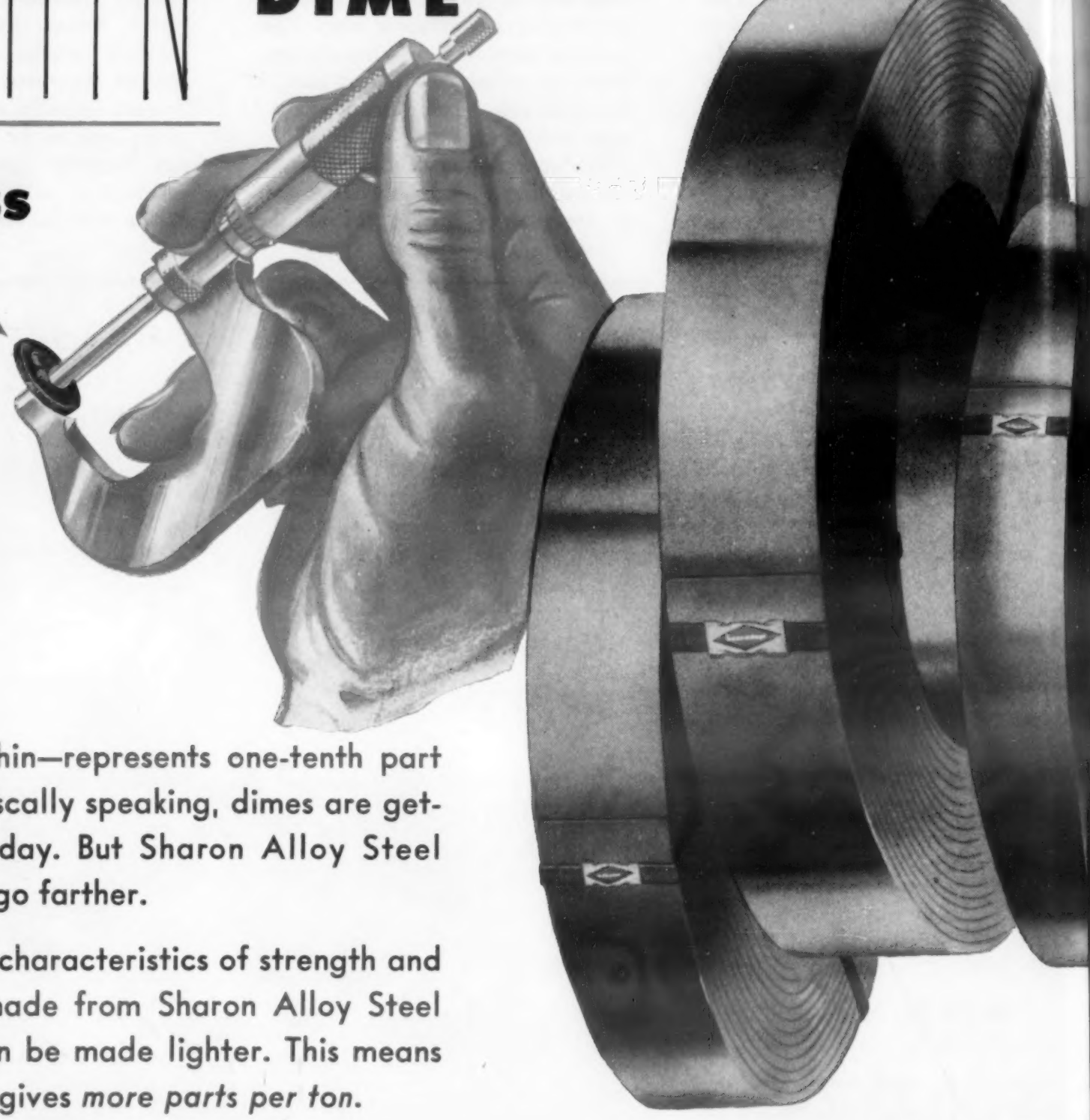
Production of small molded novelties and toys will probably be a part of the plastics market for all the foreseeable future, but the custom molder will find the industrial market a more stable, even if a lower profit, field. The molder that depends upon production of novelties only is missing an important market, and a condition that causes him to direct his attention to the molding of parts for industry may prove to be a blessing in disguise.

*"Listen to Kelly's *-*-* report on dimensions—'Bust-38, Waist-23, Hips-36, Weight-124'!"*

As to the show, it was bright and business-like, adjudged a great success by 95% of visitors and exhibitors. Attendance was 25,000, almost entirely "members of the trade." (This means that something like 100,000 molded parts such as toy scissors, ocarinas, whiskey glasses, drapery tie-backs, etc. must have been given away by the well-molded maidens brightly ornamenting several booths.)

The injection molding machines in operation attracted most interest, but the materials producers, with the largest booths, overflowed with glamour and glad-hands. A compression molding machine with many of the operating features of injection equipment was one center of interest. Another was a forced convection oven designed for efficient preheating of preforms. Several booths displayed refrigerator door liners of laminated paper-base phenolics, which were evidently among the largest formed

ONE THIN DIME



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plastics parts yet made. A continuing trend toward post-forming was in evidence.

Some remarkable and beautiful things are being done with plastics in the house-furnishings field—vinyl upholstery, floor tile, shower curtains and draperies, and woven polyethylene upholstery being typical. Vinyl paste resins aroused the interest of many visitors. Phenolic plastics and laminates made with them continue to dominate the field of industrial products, both electrical and mechanical, but a number of newcomers with special high temperature, dimensional stability, water-absorption or impact characteristics—*e.g.* allyl, cellulose propionate and polystyrene plastics—are making notable progress.

Bethlehem's Tool Steel Dept.

An extensive modernization and expansion of the tool steel department at the Bethlehem plant of Bethlehem Steel Co. has just been completed and we, along with a few other editors were invited to look over results.

Before the war Bethlehem began an extensive survey of the tool steel field. Its completion had to await war's end. Through this survey they concluded that the field for tool steels was still growing, despite the introduction of carbide tools and the like. There is hardly a finished product today that somewhere along the line has not been touched by a piece of tool steel. Even in plastics and woodworking tool steels are used for shaping and forming.

The modernization program at Bethlehem concentrated chiefly on the heating and cooling phases of tool steel production. Fully aware of the great care required in maintaining internal soundness in the many tender, heat sensitive types of tool steels, equipment has been provided for controlled cooling and inspection after every forging and rolling operation. All furnaces used for this purpose, as well as the heating and annealing furnaces, have been equipped for automatic control.

A very important addition to the department is a mill depot, with storage space for the great variety of tool and special steels that are produced. It was emphasized that prompt and efficient delivery is an important consideration in the competitive tool steel business. The new mill depot is designed to speed up deliveries to distributors, jobbers, and mill customers.

Bauxite and Zombies

For the bizarre, exotic and adventuresome life, give me the mining engineer. In his quest for vital minerals and metals he scours the malaria-infested regions where crocodiles, tigers, snakes, black men, yellow men and pigmies mingle—the mingling is usually involuntary.

We read about a quest for bauxite by the engineers of the Permanente Metals Corp. in their own house organ, *The News*. They scoured South America and islands of the Caribbean, with most of their work in Surinam (Dutch Guiana).

The natives of Surinam, called Djukas, are descendants of slaves who ran away from banana and sugar plantations, escaped to the jungles and resumed their primitive ways. Their religion is the Voodoo cult of Zombies and witchcraft and both sexes tattoo their bodies. They make a pattern of surface cuts, put rice or dirt in the sores to make them fester, leaving a "beautiful" scar design.

You'd chuckle to watch them cut down a tree. They chop or saw the trunk from all sides, never knowing which way the tree will fall. As the tree starts to sway they run wildly in all directions. After it falls they call the roll to see if all are alive, then rush up to the stump, shake hands and congratulate one another on survival.

The bauxite-seeking engineers did not have to apply to the equivalent of a U. S. employment agency for workers. By grapevine the word was spread, some coming from as far away as an 8-day canoe trip. Three hundred workers were recruited. No Djukas would give his correct name lest a "hex" be placed on him by some evil witch so each worker assumed a new fictitious name each day. At length the engineers put metal dog tags with numbers on each. They signed their receipts for cash wages with their fingerprints.

The engineers, glad to escape from strikes and paralyzed utilities in the U. S., encountered in their stead mosquitoes, chiggers, ticks, gnats and various other insect gremlins. They did not dare eat vegetables grown by natives, so were content with beans out of cans. They encountered black pantners, tigers, ant-eating bears and snakes. The natives once chased a tiger out of camp with flaming sticks. One of the native boys was bitten by an 8-ft. bushmaster, a most deadly snake. The witch doctor gave him a brew of herbs, caterpillars, beetles and monkey tails, stirred with the jawbone of a tiger—and he was cured at the cost of $7.50 (a little steeper, perhaps, than American medical fees).

At the farewell party there were Voodoo drummers and chanters, native brews, jungle juice and special French stock. Natives danced the musical equivalent of "It's always fair weather when good fellows get together."

The six engineers are now home again and the various samples of bauxite are being analyzed. Surely, after all that effort, some good will come!

Industrial Furnace Makers Meet

Don't ask: "How's business?" It is more to the point to ask: "How's profits?" There is too much business at no profits. That was one of the interesting themes developed by C. H. Stevenson, Lindberg Engineering Co., who read a paper before the annual convention of the Industrial Furnace Mfgrs. Assn. at Hot Springs, Va. recently.

Mr. Stevenson commented that everywhere he went people greeted him in the usual way—"How's business?" But what business happens to be at the moment is by no means the important thing. Perhaps you have secured some of your business by undercutting your competitor, resulting in a no-profit sale.

The theme of this year's meeting was "Reducing Costs and Improved Selling Methods." Key speakers were: W. E. Borbonus, R-S Products Corp.; H. M. Heyn, Heat Treat Div., Surface Combustion Corp.; George Tall, Leeds & Northrup Co.; with guest speaker, William B. Spooner, Jr., industrial counsel, New York, on "Using All the Tools to Sell This Industry's Equipment."

A feature of the meeting was the planning for cash awards for authors of articles on most outstanding applications of industrial furnaces and ovens. The next meeting will again be held at Hot Springs, May 3-5, 1948.

The MATERIALS OUTLOOK...

Too Many Want Cyanide Salts

If substitutes for cyanide salts in heat-treating and plating can be used, they should be considered. Supplies have tightened sharply and the quality of imported cyanide from France and Sweden is unusually poor. However, a new du Pont cyanide plant is scheduled to be completed in the fall which should relieve the situation somewhat.

Pig Iron More Cheerful

The worst days of pig iron scarcity are over. U. S. production for first quarter was over 14,600,000 tons against over 8,000,000 for the corresponding quarter in 1946. Moreover, production becomes constantly more efficient and voluminous, with even greater strides ahead by using oxygen in the blast. An important contributing factor, too, is the longer life of linings. Twenty-five years ago linings would last long enough to produce 500,000 tons of iron; today the life is 2,000,000 tons. The larger size of furnaces of this era also makes for longer life.

Natural Rubber the Cheaper

Despite early predictions that a price premium would apply to natural rubber over synthetic, it is working out contrariwise. Indications are for the natural to sell at 16c per lb. (having dropped from 21c in early May) with the synthetic at 18c. In 1947 plantation rubber will provide 50% of U. S. needs. Damage done to plantations of the Dutch East Indies and Malaya by the Japs was slight as the Japs wanted rubber for themselves and there was no time for last-minute destruction before surrender.

Tin's Rivals Rarin' to Go

It is virtually unanimously agreed that tin prices are destined to be held at at least 80c per lb. for a long time. Here is the way the British, the chief controllers of tin, look upon four rivals. Aluminum is in "full flood supply" and is taking the place of tinplate such as kitchen pots and pans and nonfood packs. Stainless steel replaces tin in kitchen utensils, electric appliances, railway cars, etc. Glass has been effective in the "packet" field, such as shaving soap and powders. Plastics have a big "pack" future. Bottle tops are here; plastic bottles are on the way and a plastic can is feared. Even a plastic gear wheel is being made. As to tin, a deficit of 76,000 tons in the next three years' production looms due to slow delivery of dredges, lack of coal and discontent among workers.

Polyethylene Is Cheaper

That popular and useful plastic, polyethylene, was reduced in price a third time June 2 so that the present quotation of 49c (56c for colored compounds based on this resin) is 51% lower than in mid-1942. Developed during the war for coaxial cable insulation for radar, its low-loss electrical and other good properties make it adaptable for many peacetime uses—deep freeze food bags, woven upholstery, ice cube trays, liners, gaskets, etc. It can be extruded, molded and fabricated into sheets and film, and coated on paper and fabrics.

Metal for Die Casting

Some die casters may soon be planning to shift some of their work from zinc back to aluminum, as they did during the war. During 1943 and 1944 production of aluminum die castings was twice output of zinc castings because of shortage of zinc. In 1945 and 1946, however, things were more normal again, with zinc castings production more than twice that of the aluminum die castings. Here in 1947 zinc die casters are lucky to get 60% of their needs of special high grade zinc, 99.99 pure. Though the U. S. has 19% of the world's zinc reserves, our supply will last only 19 years at pre-war consumption and even less at present consumption.

Zinc die casters alone want 270,000 tons this year—but won't get it. So, better look ahead and have an "ace in a hole" in the form of aluminum—and start educating your own customers.

Aluminum Spotty as to Supply

Aluminum producers have as a goal 10-cent aluminum (as against 14c now), but present high wages and transportation costs prevent price reductions. Both Reynolds and Kaiser interests have a surplus of aluminum ingots which they suggest the government buy for stockpiling. Alcoa, however, has a shortage. Reynolds argues that Uncle Sam should stockpile aluminum pig and not bauxite, thereby actually stockpiling, too, electric power, manpower and time.

Antimony to Continue Short

It'll be a scramble to get enough antimony for a long time. Bolivia has been eliminated as a major source of imports and the Chinese antimony industry has broken down. Our consumption in 1946 was 8000 tons in excess of imports and home production, the balance coming from government stockpiles. But there isn't any more in the Uncle Sam kitty. Thus antimony, like alimony, may become embarassingly short.

Gray Iron Supply to Stay Tight

Although gray iron foundries produced 15½% more during the first quarter, 1947, than for same period of 1946, the availability of gray and malleable iron will show little, if any, improvement over the next many months. There are still severe shortages of pig iron and coke, plus labor troubles. Prices of castings will not go down over the next few months—they might rise.

AN EDITORIAL

The Busy Reader

Once upon a time there was a plant engineer named Herman who was a very busy man indeed. His working life was filled with assorted problems related to the manufacture of electric motors—what to make them out of, how to machine and harden them, where to obtain all the incidental materials and operating accessories necessary to their production, what to do when production breaks down or rejects pile up, etc.; but especially, how to carry out the hundred and one weekly missions assigned to him by his two bosses, the works manager and the chief engineer, who seemed to Herman individually to combine the qualities of Nero and Simon Legree.

The reason Herman was so busy was that he was very competent and extremely knowledgeable, especially about the methods of working and assembling the various materials that go into electric motors. And the chief reason Herman was so well informed was that he had for years been an avid reader of the technical magazines that touched on his problems. But now he had gotten so busy that he had very little time left for reading. And all of a sudden Herman realized that he hadn't looked at a trade paper (or any other reading matter except orders, bills, memoranda, complaints, reports and specifications) for three months. He turned a cold and fishy eye on the mountain of magazines on his office table—*Materials and Processes, The Steel Age, Product Design, American Machinery, Metallurgical Progress, Electrical Production, Factory and Mill Management, Modern Manufacturing,* plus magazines on welding, tooling, heat treating, forging, finishing and testing, and every one augmented by a sort of competitive twin! Because he could no longer read everything, he had taken to reading nothing, and this he knew was the first step in the reduction of his value to his company.

Right then Herman made his great decision, his self-emancipation proclamation. Henceforth, he declared, I will not feel obligated to read every journal that comes into my office, nor even to glance at same. But I will positively read thoroughly those few magazines (1) that directly and primarily bear on my important functional problems, and (2) which are alertly and systematically edited to provide me in convenient form, with the technical news and process information I need in my work.

Then he dove into his pile, which now numbered 60 copies of 14 different magazines, scrutinized each publication carefully and finally settled on four magazines—four good publications which covered as a group the same ground as all 14, yet which specifically featured the kind of news and technical information essential to his work. With the combination chosen he could obtain all the detailed information needed for his job, in convenient and uncluttered form—new materials, processes and manufacturing equipment; working methods for various materials; trends in engineering design; advanced practice in the operation of production machinery; and general news of his industry and other metalworking fields.

Herman is now happy. He's just as busy as ever—if anything even more in demand. But he found the way to keep up-to-date technically without becoming engulfed in an endless wave of magazines and to restore his normal serenity. And—as usual—his bosses adopted his practice too; they stopped subscribing to the weak publications, read the most important of the strong ones themselves and directed the rest of the staff to follow Herman's systematic example.

All publishers of strong, functionally-edited industrial magazines wish many others would go and do like Herman.

FRED P. PETERS

EDITORIAL COMMENT

Edwin F. Cone Retires

Edwin F. Cone, one of the ablest and most experienced industrial journalists in this country, and for many years Editor of this magazine, is retiring this month from the staff he has led and served since 1935.

Mr. Cone was graduated from Buchtel College in Akron, Ohio, and the Case School of Applied Science in Cleveland. He served the Grasselli Chemical Company and later the American Steel Foundries in chemical and metallurgical capacities, and then joined "The Iron Age," of which he was Associate Editor for 20 years.

In January 1935 he was appointed Editor of this magazine, then known as "Metals and Alloys." During his 8-year tenure of that position, "Metals and Alloys" saw its most spectacular growth. He broadened and practicalized its editorial approach to such an extent that the magazine's circulation more than tripled in that period. In 1943 he turned over the increasingly heavy load of editorial management to a younger associate, but continued, as Consulting Editor, to help guide the magazine in its policies and to write many of its most interesting articles and editorials.

Editors characteristically develop a wide acquaintanceship and few industrial editors can match "Doc" Cone's roster of friends in a dozen fields. He is a member of the American Institute of Mining & Metallurgical Engineers, the American Society for Metals, American Society for Testing Materials, American Iron & Steel Institute, American Foundrymen's Association and The Electrochemical Society, and has held numerous offices in several of these. He has been especially interested, both through committee work and editorially, in steel and its uses, and much of his published work on high-strength steels, electric furnace steels, stainless and alloy steels, refractories, centrifugal castings, etc. will remain a constant source of reference for many years.

The publishers and editors of "Materials & Methods" are proud and grateful that Mr. Cone capped his long and distinguished career with his service on our behalf. And we know that all of his friends among our readers will join us, his envious associates, in wishing him many many years of happy leisure.

—The Editors

Two Schools of Engineers

How effective is the liberal arts school graduate who majored in science when he competes in industry with a graduate from a technical school? This topic was expounded by the head professor of chemistry of mid-western liberal arts college, next to whom we sat at a recent luncheon. Prof. Liberal Arts, let's call him, had been somewhat concerned with this question. So he wrote to one of the leading scientists in the atom bomb project, himself a college professor, asking this question, since Prof. A. Bomb (shall we so designate him?) had supervised a large group of chemists, some from liberal arts schools and others from technical institutions. "Chemists" versus "chemical engineers"!

"The liberal arts scientist seems at a great disadvantage at first. He is confused, slow in getting started, and apparently lacking in confidence. After a while, however, he matches and perhaps overtakes the technical school graduate," Prof. Bomb observed.

"The liberal arts graduate usually writes better reports on his project. He has a better conception of the project as a whole. He can quickly differentiate between the basic facts and the irrelevant and trivia. Apparently his broader education, involving economics, history, languages, English, etc. have given him vision, imagination and other qualities which make him master of the situation."

The liberal arts graduate has largely stuck to basic principles and has not cluttered up his brain with many technical details. He has confined his scientific studies largely to the realm of "pure science." Since he has not specialized much in his early and formative years, he is perhaps more adapted to shifting rapidly where necessary.

Deans of the highly technical and engineering schools are themselves taking steps to install more courses of the liberal arts group. They are emphasizing the mastering of basic principles and placing less emphasis on the intricate details of any one technique.

As a matter of fact, it might be well if each type of school would borrow a little of the philosophy of the other type. One must not overlook, either, that in the long run it is the individual that counts. Many an individual technician, with no advanced schooling, has proven the equal or peer of the individual who was nurtured within collegiate ivy-clad walls — H. A. K.

Do We Need Basic Research?

In a talk before the recent meeting of the American Iron & Steel Institute, Cyril Smith said: "There is no doubt that the whole surface of civilization has changed as a result of pure science. This is true, it is self-evident, yet the metallurgical industry on the whole acts as if it were not true." We venture to add that this criticism is true not only in the metals field but applies as well to our entire industrial establishment.

We as a nation have built up for ourselves a set of values in which the direct, the immediate and the obvious things such as high volume production and variety almost always are rated most important in our minds. We find it very difficult to comprehend the value of fundamental research, because it has no immediate tie-in with current industrial production. Our imagination has become limited to "practical" things—to tangible short-range product and material developments whose future values can be predicted in dollars and cents.

But this attitude or philosophy of ours may have to change if we are to continue to progress. As Cyril Smith also pointed out, "we are reaching the point where the law of diminishing returns has set in and further advances will be both slow and costly.—There is little chance of major improvement in the properties of metals by a continuation of experiment along the lines of making new compositions and putting them through variations of conventional heat treatment. Improvements of 10%, perhaps somewhat more, will be so found, but shall we overlook the possibility of making metals twice as strong as at present, five times . . . ?"

We can't overlook such possibilities because metals that are two to five times stronger will probably be required to meet the design requirements of future nuclear power plants, gas turbines and the like.

To meet this challenge for better materials requires that a number of fundamental questions of *why* be answered. To mention only a few from Dr. Smith's paper: Why do metals resist stress elastically? Why do they plastically deform? Why do slip and fracture occur at such low stresses when the forces holding metal atoms together in the crystal are at least ten times as large? These and many other questions must someday be answered before the great advances in materials that are so necessary for future progress can be made. Only through basic research can the answers be obtained and, therefore, it should be wholeheartedly supported by all of us.

—H.R.C.

Materials & Methods
THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE
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Expect Sheet Steel Shortage to Extend Until June 1948

by HAROLD A. KNIGHT, *News Editor,* MATERIALS & METHODS

THE EDITORS OF MATERIALS & METHODS consider as one of their duties to readers the regular reporting on immediate and long-term availability of the principal engineering materials. Since a true knowledge of materials requires information on supply as well as on the physical and working properties of materials, we herewith present another special report.

For the past several months, there has been a welter of charges, claims and counterclaims concerning the scarcity of sheet steel. Official government cognizance of the tight finished steel situation resulted in the hearings before the Senate Small Business Committee. In an attempt to determine just how severe the shortage is, learn if possible where the fault lies, and throw some light on when the shortage might end, MATERIALS & METHODS conducted a survey among sheet steel producers and representative users of this material in various types of industries throughout the country.

Summarizing the findings, we learn that most companies expect the shortage to be history by the end of June 1948; that industry is receiving an average of 28% less steel than it feels it needs; and that a greatly swelled demand for finished steel combines with restricted rolling capacity to provide less than the desired quantity.

The facts and conclusions presented here are published in the belief that they might aid both producers and consumers of sheet steel to plan more intelligently for the future months.

Undoubtedly, steel sheets are the scarcest forms of steel and the key steel for the most-sought-after consumer's durable goods in the form of automobiles, refrigerators, washing machines, stoves and cooking ranges and scores of other goods in this class. By many, steel sheets are regarded as the country's No. 1 scarcity.

There appears to be rather general agreement between producers and consumers on the situation. Both, for instance, agree that the shortage should be over by mid-1948. Both agree fairly well on what grades and descriptions are weakest. In the main, there is agreement that sheets are being allotted fairly by the mills. The chief disagreement comes as to the extent of the gray market. Sheet producers consider it negligible, but 90% of the consumers canvassed have been approached by operators in the shaded market—one 25 times; another is approached daily.

But first, a brief analysis on the reason for the particular shortage in sheets. During the war, sheets were a minor war material and production lagged in favor of other more war-useful items. In 1939 sheets were 25% of total steel shipments, dropping to 14% in 1942, 13½% in 1943 and rising to 15% in 1944, 19% in 1945 and 24% for the first four months of 1947.

Several sheet mills were converted to plate mills during the war and the small production of sheets during the war left but little surplus for peace uses. There has been some testimony that flat-rolled products, particularly hot-rolled sheets, are among the less profitable forms of steel in the present price pattern. However, when we asked sheet producers if higher prices for hot-rolled sheets would improve the supply situation, they unanimously answered "No."

Emphasizing the seriousness of the sheet steel scarcity was the testimony before the Senate Subcommittee by an official of the Edgecomb Steel Corp., Hillside, N. J., a warehouse firm, or jobber. He said that because of this shortage several of the company's customers have gone into equity receiverships.

Consumers' Questionnaire in Detail

The first question asked consumers was the extent that they had curtailed production of their own products because of sheet shortage. Eighteen per cent had experienced no curtailment, and in other cases curtailment had ranged from 2 to 60%, the last figure prevailing for 10% of those curtailing. Average production cuts—for those who so suffered—was 28%.

The question of what kinds of sheets are the

scarcest evoked no uniformity of opinion, thus lending much credence to a statement by a producer that "all grades are scarcest." Light gaged sheets and enameling sheets received the most votes in a scattered field.

When asking enumeration of most plentiful, again there was a lack of concentration. Tied for first place were hot-rolled and cold-rolled low carbon sheets, and stainless steel.

As to guesses when sheets will become plentiful, the range was from fourth quarter, 1947 to second quarter, 1948. Here opinion was preponderantly in favor of June, 1948, (or a year from the date of the questionnaire).

The most uniform agreement was on the question as to whether these makers of automobiles, refrigerators, washing machines, ranges, metal furniture, etc. had been approached by gray marketeers. At least 90% had been so approached, and one company admitted to "buying to some extent." One party was approached by mail only. (The president of the Pressed Metal Institute recently told his membership that specific firm-sales offers of over-priced steel sheet and strips aggregated over 1,000,000 tons at prices ranging up to $250 per ton.)

We asked them whether they have been using aluminum or other materials as a substitute for steel. About half had, ranging from one using aluminum to the extent of 33⅓% down to four "in a limited way." One had tried but found the substitute unsatisfactory. Queried as to whether the substitute would be permanent, the majority answered negatively, a fifth said in a few cases and one suggested it depended on price relationships.

An interesting question involved the fairness with which sheets are being apportioned. At least a third answered unqualifiedly "yes;" a fifth gave a curt "no;" a few said "mostly, yes." One commented: "Reputable mills have tried but this quota business built up the black market. Some steel officials could have done a better job." Another answered: "They say they're doing it fairly but it is hard to understand when production is often up to 102% of capacity among several sheet mills." It is our own impression that the sheet producers are doing their best to take care of small business because Washington serves as the "Great White Father" towards the little fellow. An auto manufacturer remarks that the Automobile Manufacturers' Assn. has shown that their industry is receiving 30% less than their share. One said the steel makers persuaded consumers to use more steel in place of wood, etc.—then cut them off from steel.

As to quality being up to standard, about 50% claim "no." One-fifth say unequivocally "yes," a few say "mostly yes." One remarks that quality is 30% below standard; another observes that working qualities are standard, but finish not; another finds standard quality obtainable from only one source. One says not as good as usual, particularly in enameling grades; one says that he offsets inferior quality by extra finishing at his own plant.

Before the Senate Subcommittee the Edgecomb Steel Corp. observer said that deliveries to his warehouse are mainly over-runs and rejects and odds and ends of sizes which the warehouse shears up into some form of salable sheets. Besides these eccentric sizes, the quality is poorer.

What the Producers Say

We asked the producers what grades of sheets are scarcest. Cold rolled steel and galvanized were the popular choices in a rather wide assortment. Among other grades mentioned were hot rolled, annealed; enameling sheets and silicon electric. Two producers, with sweeping gestures, mentioned "all flat-rolled products."

As to what delivery they are quoting on these scarcest sheets, most were out of the market for the rest of 1947, though one ventures second and third quarter, 1947.

We asked if sheet producers are expanding capacity and to what extent, but answers were mostly negative. One producer mentioned 17%, another 40% and another 200%. In fact, Inland Steel Co. has announced publicly that it is engaged in an $18,000,000 program to enlarge sheet steel facilities, but strikes and materials shortages have delayed completion for a year, or well into 1948. Even without the new facilities Inland's sheet production in first quarter, 1947 was 45% of total steel production as against 30% in 1939-1940. Of its total 1946 production, Inland shipped 18% to warehouses (to supply the small business) as against 16% in 1940.

The American Iron & Steel Institute had estimated that sheet-working capacity would have increased as of July 1, 1947 since V-J Day by 2,500,000 tons, but now realizes that the program is far from being accomplished and is making a survey to see what percentage is being fulfilled. The chief bottleneck has been electrical equipment for rolling mills, particularly motors. The long strike at Allis-Chalmers proved a factor to narrow that bottleneck.

Speaking on the same subject before the National Assn. of Purchasing Agents, David F. Austin said that when facilities are completed sheet and strip shipments will rise from the previous all-time high of 16,000,000 tons yearly to over 19,000,000. Speaking of the industry as a whole, he said that capacity is being used for maximum production and for the first time in peace total capacity fails to meet total demand. He forecast that a balance between supply and demand in most steel products will be reached by the end of 1947.

On the question, "When will you again quote normal delivery periods?" the producers did not seem to have as decided opinions as consumers and more frequently refused to hazard a guess. However, several votes were given for mid-1948 which coincided with the leading opinion of consumers.

As to the existence of a gray market, those who admitted it were 7 to 1, ratioed against those denying it. As to whether this gray market is an "important factor," they unanimously replied "no." One producer said: "It is important that the black market be stamped out to prevent inflation and to protect the honor and integrity of the steel industry and the faith that the public should have in it." Asked as to

how extensive is duplication of orders, the great majority voted extremely light, if at all. One estimated that 15 to 20% of the national backlog of orders is duplication.

Producers were queried as to whether a rise in price of hot-rolled sheets would increase output of that grade. The answer was "no" except in three cases. However, R. C. Todd, vice president, American Rolling Mill Co., testifying before the Senate, said that hot-rolled steel will be further withdrawn from production as cold-rolling capacity is increased, unless prices are adjusted so that hot-rolled will stand on its own feet, profitwise. One made the logical observation that since all sheet producers are already working at full capacity, higher prices could not further increase output.

As to what caused the sheet shortage, no unusual answer was forthcoming. Among reasons advanced were six years of accumulated demand, strikes in steel and coal, gas shortage; greater profit in other steel items and the fact that there had been up to date no capacity increase since pre-war.

When it was propounded whether producers had plate capacity destined to be converted to sheet manufacture, only one replied affirmatively.

A significant remark was that peace time uses for sheets demand more processing than for war uses where many ordnance items are expendable. Thus, peace time demand is high for deep-drawing steel and galvanized steel in lighter gages, all requiring 5 to 15 days additional processing time.

Some Other Aspects

Reasons for the 5½% gray market call for some expounding. If one can understand the causes perhaps steps can be taken to eliminate it. Much of it has come from steel with Government priority rating for veteran's housing, only to have the project be abandoned, the steel falling into the hands of speculators. Other has come from steel originally earmarked for export, but diverted. In other cases it is surplus steel that consumers did not need—often obsolete sizes that consumers disposed of to reduce unbalanced inventories.

Again, according to an estimate of the American Iron & Steel Institute, establishments fabricating iron and steel in 1946 were 64.7% more numerous than in 1939, or as 33,600 consumers in 1946 compares with 20,400 in 1939. Inasmuch as sheet steel shipments normally run 25% of total sheet shipments, it is probable that a quarter of this total gain in steel consumers is by those whose major steel material is sheets.

In fact, the rise may surpass 25% inasmuch as the tendency has been to use flat-rolled products in larger proportions than ever. Thus domestic stoves, of sheet steel, tend to supplant the old cumbersome cast iron stoves. The great growth in the use of steel stampings is another indication of sheets' supremacy. For example, one maker of a modern brazed into an assembly, in place of former heavy automobile engine uses sheet steel stampings, copper and bulky steel castings, wherever possible.

Although a "grey market" in steel definitely exists, it makes a noise all out of proportion to its total effect upon either users or producers of steel.

Our Own Conclusions

From our own study of the current steel sheet scarcity and experience with steel markets and economics over many years, we draw some conclusions of our own which may vary here and there from opinions as expressed in the questionnaire.

We doubt that black market steel has been over 1% of total sheets made and sold as against 5½% elsewhere estimated. We believe that demand and supply will be well balanced by Dec. 31, 1947 and for the following reasons: Labor-management relations will be smooth over the rest of 1947 and sheet production will be tremendous. The "pipelines" in many finished goods are by now filled, such as radio receivers, washing machines, steel furniture. There has actually developed considerable unemployment in radio receiver manufacture.

Again, the bloom is off export business as dollar credits in foreign countries for buying American goods are about exhausted. Moreover, high prices of goods tend to promote boycotts, both here and abroad. Manufacturers have become clever in using odd sizes and shapes of sheets for finished products—pieces that formerly would have been scrapped. They weld together little ones to make big ones.

Distribution of sheets has become better as business has better settled down after early post-war confusion. Questionnaire answers to the contrary, several substitutes have been found, such as laminated plastics, aluminum, magnesium, etc. Stainless steel sheets are genuinely plentiful and will take much burden off carbon sheets.

The April steel output as reported by American Iron & Steel Institute shows that 1,566,932 net tons of sheet and strip was shipped during that month. This output is at an annual rate of over 19,000,000 tons. At the May annual meeting of the Institute, its president, Walter S. Tower, recalled that during the first year after the first World War it was a "steel-starved" world. The following year operations in the industry were down to 35% of capacity.

Finally, so much publicity has been given at Washington and elsewhere, on the sheet steel scarcity, that the steel makers will exert unusual efforts to remedy the situation.

Protecting Surface Finish with Strippable Plastic Coatings

by H. R. CLAUSER, *Associate Editor,* MATERIALS & METHODS

MANY METAL WORKING OPERATIONS involve the handling, forming and assembly of materials with highly finished and semi-finished surfaces. Protection of these surfaces during the various stages of product manufacture is an important consideration. It often limits or influences the processing methods used; and when surfaces are scratched or marred it is usually a costly matter to bring the surface back to the required finish.

A successful solution to this problem of protecting surface finish during manufacturing operations is now possible in many cases through use of the relatively new strippable plastic coatings. By applying these coatings to stainless steel or aluminum, for example, the material can be shaped by many of the common forming methods without marring the finished surface; after the piece is formed and assembled the protective film is easily peeled off. This is only one of a wide range of applications which have been developed. These strippable coatings have also found successful use in protecting polished surfaces before forming and also during such fabricating operations as machining, punching, welding, and selective finishing.

It was during the war that strippable coatings first received wide use. Their principal application then was for protecting war material, such as planes, tanks, guns, tools and spare parts from the atmosphere and superficial damage while being stored and transported.

Whenever and wherever metals are handled either during manufacture, storage or shipment there is a problem of protecting their surfaces. There are now three general types of plastic coatings available which are easy to apply, removable, and which protect against both moisture and marring.

At the same time some use was made of strip coatings as a protective covering on metal surfaces and plastics during processing operations. But only since the end of the war, when the demands of war material packaging decreased, has their use expanded as a protective covering on surfaces during manufacturing.

Strippable plastic films are unique among protective coatings. Normally coatings are designed to adhere tightly to surfaces without peeling, but strip coatings are designed both to stick to the surface and at the same time be capable of being peeled off in large strips. To achieve this, strippable coatings must have: (1) Sufficient adhesion and elasticity to stick to the surface without breaking during manufacturing operations, and (2) good tensile strength, so that the film can be stripped without breaking. There are other characteristics that are also important in the selection and use of strip coatings. These include types of materials and finishes to which they can be applied, temperature range within which the film will not be affected, methods of applications, drying time, safety and working conditions, coverage, film thicknesses, and cost.

At present there are three general types of strippable plastic coatings: (1) solvent types, (2) water dispersion types, and (3) hot melt types. The solvent and water dispersion types are the most widely used for surface protection during manufacturing operations, the hot melts being in general confined to packaging applications. However, they do have some other uses such as protecting sub-assembly surfaces in storage or during intra-plant shipment and assembly and as stop-off masking in electroplating operations.

Since there are a great many formulations being produced by a number of different companies, it is impossible here to give a specific set of characteristics for each type of coating. Also, many of the strip-coating producers formulate their compounds to suit particular applications and to emphasize certain film properties. So, in this article we will discuss in a general way the nature, characteristics, properties and uses of the three general strippable coating types.

Solvent Types

The solvent type strip coatings have a base of either vinyl polymers or cellulose acetate butyrates which are carried in volatile solvents. Upon application, the solvent evaporates, leaving an elastic plastic film.

This stainless steel sink was pressed with a solvent type coating on its surface to protect the finish. (Courtesy of Better Finishes & Coatings, Inc.)

Solvent type coatings may be formulated to meet a variety of appearance requirements. They can be made to be opaque or transparent on a surface, and also are available in any solid or pastel color. The dry film is odorless, and non-toxic.

Solvent strip coatings can be used on all bare metals and alloys and also on surfaces finished with high temperature bake paints and vitreous enamel surfaces. However, they will attack air dry paints and lacquers, with the exception of most lusterless camouflage paints. They can be applied on thermosetting plastics, but not on thermoplastics.

Solvent strip coatings are applied to surfaces by cold or hot spray, cold or hot dip, or by brush and roller methods. Spraying, particularly cold spraying, seems to be the most widely used method of application, because for many jobs it is most economical. In production operations, automatic spray or roller application can be used successfully. In spray applications, any standard spray gun can be used. However, certain air caps, fluid tips and needles which are standard for spraying high viscosity fluids must be used for best results. Also, a pressure-feed system, and not a vacuum-feed, must be employed. In dipping, regular dip tank equipment is suitable.

Coatings of the solvent type dry rapidly; the drying rate can be adjusted to some extent to suit the application. An ordinary air dry permits the coating to be touched in 5 to 20 min., and subjected to abuse in 1 to 5 hr., depending on the film thickness, room

Principal Producers of Strippable Coatings

Type	Company	Trade Name
Solvent	Better Finishes & Coatings, Inc.	Liquid Envelope
	Eronel Services	Spray Peel
		Eronel #515 (butyrate)
	E. M. Hollingshead Corp.	Cocoon Scuff Coat
	Interchemical Corp.	Protektol
	Naugatuck Chemical Div., U. S. Rubber Co.	Kotol
	Stoner-Mudge, Inc.	
	Merchants Chemical Co.	Dyna-Flex
Water Dispersion	Eronel Services	Protecto-Plate
	Spraylat Corp.	Spraylat
Hot Melt	Ernst Bischoff Co., Inc.	Thermo-Cote
	Eronel Services	Thermo-Dip
	Seal-Peel, Inc.	Seal-Peel
	Seibert Varnish Co.	Plasticstrip
	Progressive Systems, Inc.	Plastic Seal
	Tennessee Eastman Corp.	Type AB-500-5
	Dow Chemical Co.	Stripcoat
	E. F. Houghton & Co.	Houghto-Kote Strip CA
	Interchemical Corp.	Protektol

Characteristics of Strippable Plastic Coatings

Properties	Solvent Types		Water Dispersion Types	Hot Melt Types	
	Vinyls	Butyrate		Ethyl Cellulose	Butyrate
Film thickness — in. (Spray — one or two passes)	0.001 to 0.003	0.001 to 0.003	0.001 to 0.006	0.040 to 0.080	0.060 to 0.080
Film strength, psi.	1000 to 2000	500 to 600	800 to 3000	400 to 700	300 to 350
Elongation	150 to 200%	75 to 80%	150 to 250%	50 to 75%	100 to 120%
Application temp.	Cold spray	Cold spray	Cold spray	350 to 380 F	290 to 325 F
Drying time (air dry)	5 to 20 min.	20 to 40 min.	20 min. to 4 hr.	2 to 5 min.	2 to 5 min.
Flash point of film	None	None	None	410 F	410 F
Flash point of solution	100 F	100 F	None	410 F	410 F
Temp. range in which film is not affected	—10 to 200 F	—10 to 200 F	—10 to 225 F	—40 to 180 F	—20 to 180 F
Coverage per gal. (0.003-in. film thickness)	100 sq. ft.	100 sq. ft.	200 sq. ft.	—	—

Shown here is a water dispersion type strippable coating being peeled off after the forming operation. (Courtesy of Eronel Services.)

temperature and humidity. For example, one particular formulation of a vinyl polymer coating will dry in an average of 10 min. at 70 F and 60% humidity in free air. It should be noted that a longer drying period is required for the film to become completely solvent free and, therefore, for it to achieve its full tensile strength. Some tests have shown that at normal room temperature it takes at least 12 hr. for the coating to be completely free of solvent. Of course, with forced drying, the time is greatly shortened. One manufacturer reports that by forced drying at 250 F the coated surface can be handled after 2 min. However, temperatures of 180 F and below are generally recommended since higher temperatures may impair the strippability of the film.

Film thicknesses possible with solvent type strip coatings vary from 0.001 in. to 0.050 in., depending on the formulation and method of application. A single spray coat (*i.e.,* one or two spray passes without intervening drying) is usually 0.001 to 0.003 in.; a single dip coat runs from 0.0005 in. to a maximum of 0.002 in. The final selection of film thickness will depend upon the service conditions which the coating must withstand.

Film (or tensile) strength and elongation of the coating material are interrelated, and these two properties can be regulated in accordance with specific requirements. The range of film strength for the vinyl polymer type solvent strip coats is from about 1000 to 2000 psi., and the elongation from 150 to 200%. The film strengths and elongations of the butyrate base coatings are somewhat lower, being of the order of 500 to 600 psi. and 75 to 80%, respectively. But the butyrate coatings are generally more abrasion resistant with less adhesion than the vinyls.

The vinyl coatings remain flexible at temperatures as low as —40 F, and do not get tacky up to 180 F. Their melting point is around 250 F. The coating itself is non-flammable after the solvents have evaporated. While applying the material it is flammable, because of the volatile solvents present.

Solvent type coatings have excellent corrosion resistance against a wide range of conditions and chemicals. The compound is chemically inert. At normal temperatures the films are highly resistant to the following: all weak acids and alkalies, salt solutions, gasoline, aliphatic hydrocarbons, vegetable and mineral oils and greases. They are attacked by concentrated acids and alkalies and are soluble in esters and ketones. They are softened by alcohol and aromatic hydrocarbons.

The surface area coverage possible with these coatings varies, of course, with the film thickness used. With an average film thickness of 0.003 in., one manufacturer reports a coverage of about 100 sq. ft. per gal.; another reports a coverage of 130 sq. ft. per gal. for a 0.001-in. film thickness; and still another calculates a coverage of nearly 200 ft. per gal. for a film thickness of between 0.025 and 0.003 in.

Water Dispersion Types

These strippable coatings are water dispersions of compounded plasticized synthetic resins. Water is the vehicle and upon evaporation leaves a plastic, rubber-like, tough film on the surface. The film is ordinarily water-white and transparent. If desired, the compounds and resultant films can be tinted any color or made opaque. The spray as well as the dried films are odorless and non-toxic.

There are practically no limitations as to kinds of surfaces on which water dispersion coatings may be used. They are suitable for all metals and finishes as well as plastic surfaces. These compounds are almost always applied by cold spraying with standard spray guns. For best atomization of the coating material, the air pressure should be between 60 and 70 psi., and there should be sufficient pressure in the spraying system to deliver an adequate quantity to the gun. The gun should be held 8 in. or more from the sheet and a fan type spray used. The coatings can also be applied by cold dipping or brushing methods.

The films can be dried either at room temperature or by using such accelerated drying methods as a forced draft of air on the surface, or infra-red radiation. Temperatures up to 150 F may be used. The thickness of the coating influences the length of drying time. Films 0.001 to 0.004 in. require from 10 min. to 1 hr. to dry to touch, depending on the specific room temperature and percent relative humidity. To achieve full tensile strength, up to 4 hr., or overnight drying is required, depending upon the mechanism of drying used. With forced draft of air or infra-red radiation, full drying to maximum tensile strength is accomplished in ½ to 1 hr. for film thicknesses from 0.002 to 0.005 in.

Water dispersion films can be applied over a range of thicknesses from 0.001 to 0.006 in. per application. An application refers to one or more spray passes without intervening drying time required. A 0.003-in. film can be deposited in one pass and a 0.006-in. film in two passes. Within this range the material deposited on a vertical plane will not run. One or two coats generally provide adequate protection.

The film strength and elongation of water dispersion type coatings vary widely, depending upon the resin used for the base. With a polystyrene latex base, for example, the tensile strength is around 800 psi. and the elongation 135 to 150%. However, with various other synthetic resins as bases, film strengths of 3000 psi. and elongations of 250% are achieved. These figures are for standard conditions of room temperature (70 F and 50% humidity). The strength

and elongation are less at reduced temperatures, but the films generally remain flexible at temperatures down to around 0 F. Likewise at elevated temperatures these properties change, but are considered capable of withstanding temperatures up to 225 F.

Because water dispersion compounds contain no volatile solvents, they are nonflammable both in spraying and as films. It should be noted, however, that some styrenes and vinyl butyrate with certain plasticizers will support combustion in the dried film form, but the majority of water dispersion strip coatings avoid such combinations.

Water dispersion coatings have wide corrosion resistance. They are unaffected by all weak acids and alkalis. They are unaffected by all mineral and vegetable oils and greases, salt water, aliphatic hydrocarbons, and gasoline. The films are softened by aromatic hydrocarbons, and by some alcohols and ethers. They are dissolved by ketones and esters.

The coverage possible with water dispersion films is relatively high because the formulations generally contain about 45% solids as sprayed. For film thicknesses of 0.003 in., the coverage runs at least 200 sq. ft. per gal. under plant production conditions.

Hot Melt Coatings

Hot melt strippable coatings, as the name implies, are applied by hot dipping the objects to be coated into the molten plastic compound. The coating compound is furnished in solid form and must be melted in a suitable tank.

There are two principal kinds of hot melt strippable coatings; they are similar to each other in some respects and different in others. One of these is basically an ethyl cellulose compound; the other has a base of cellulose acetate butyrate. Both, of course, are formulated with various other ingredients to give the desired characteristics of a strippable protective coating. In applications where corrosion protection is desired both kinds can be formulated to exude a corrosion inhibiting oil on the surface being protected.

The hot melts are non-toxic and once applied are odorless. The exuding kind of butyrate coatings are transparent and yellow; the non-exuding butyrates can be tinted in various colors and still remain transparent. Ethyl cellulose coatings vary in color from a light yellow to dark brown and purple. They can be formulated to be transparent, but must be applied at the specified temperature to avoid discoloration.

Hot melts are chemically inert and, therefore, in themselves would be applicable to almost any surface finish except painted surfaces other than high bake and vitreous enamel. However, because they must be hot dipped their applications are limited to bare metals and alloys and other surfaces that will not be affected by the high dipping temperature. The dipping temperature of the butyrates ranges from 290 to 325 F; for the ethyl cellulose types it varies between 350 and 375 F. The dipping temperature of ethyl cellulose coatings is more critical than that for the butyrates, because the ethyl cellulose compounds will discolor if the proper dipping temperature is not maintained.

The parts prior to dipping should be thoroughly cleaned. They are fastened to a thin cord, preferably fiberglas or wax-impregnated cord, for dipping and are held in the bath for from 2 to 10 sec., depending upon the coating thickness desired. The setting time for hot melt coatings is from 2 to 5 min. After this period the coating is satisfactory for handling.

The thickness of coating varies with the dipping temperature. In general a single dip gives a film thickness of 0.08 to 0.15 in. It is possible, of course, to obtain heavier coats by two or more dips.

Hot melt films have a tensile strength varying from as low as 300 to as high as 600 psi. In general, the butyrates have lower film strengths than the ethyl cellulose types, but have greater elasticity. Their elongation is 100 to 120% as compared to only 50 to 80% for ethyl cellulose coatings. A butyrate type hot melt is now being developed which is expected to have a film strength of about 520 psi. and an elongation of 190%.

Hot melt coatings are stable and maintain effective protection at temperatures from around —40 to 160 F. Their flash point is 410 F, and since no volatile solvents are used, they are nonflammable during application. Since their fire point runs up to around 450 F, the coating itself is nonflammable for all practical purposes. They resist corrosion under practically all climatic and weathering conditions and salt spray. They also are not affected by dilute acids, but are attacked by concentrated forms of acids, alkalies and alcohol.

Applications and Costs

Because of their ease of application by spraying as well as their relatively high film strength and elasticity, the solvent and water dispersion types of strippable coatings are most suitable in the metal processing field for protecting surface finishes during handling and fabricating operations. Polished sheets of metals such as stainless steel, Monel, brass, aluminum and magnesium can be coated at the rolling mill before shipment to the warehouse or customer, thus protecting the surface from superficial damage in transit.

In metal forming and fabricating shops these strippable protective films prevent scratching and blemishing of surfaces during forming operations such as pressing, cupping or drawing. They can also be used to protect finished surfaces during machining, cutting and sawing, and welding operations. For

A group of typical parts and tools protected from superficial damage with hot melt strip coatings. (Courtesy of Seal-Peel, Inc.)

Strippable coatings protect surface finish even during deep forming operations.

example, many manufacturers of hospital and kitchen equipment spray the stainless steel sheet with a strippable coating before forming and do not strip it off until after the shapes have been punched, welded and assembled into finished units. In some of the forming operations presses up to 16,000 tons capacity are used.

Another manufacturer, who produces motor coach parts of stainless steel, protects the metal surfaces throughout all the forming and fabricating operations. Many of the shapes involve 180-deg. and "Z" bends on a press or bending brake. In such operations the coating is believed to aid in cushioning the reverse bends and prevent fissure cracks on the surface.

Aircraft manufacturers first used water dispersion coatings to protect Plexiglas and Lucite sheeting from nicks, solvents, grease and dirt while being formed and assembled as bomber noses, plane turrets and cabin inclosures. Now its use has been extended to protect metallic sheets while being drilled, rolled, bent, stamped and assembled. Since water dispersions do not attack painted or lacquered metal it is also being extensively used on such finished surfaces to protect them against scratches and dirt during fabrication, storage and shipment.

An important use of solvent and water dispersion type coatings is as a masking material during painting. They are also excellent for coating paint spray booths. Thus, after excess paint has accumulated, the coating with its deposit of paint can easily be stripped off. A unique application has been reported in which strippable coatings are used to protect portions of metal parts during sand blasting.

As mentioned earlier, the hot melts are generally limited to packaging applications. These uses include protection of tools from corrosion and injury while idle and protection of spare parts which are to be stored for future use, or small subassemblies during intra-plant shipment.

Hot melt strip coatings have proved satisfactory as a stop-off in plating operations. They can be used on parts requiring as long as a 48-hr. plating period at temperatures up to 160 F. In one plant the butyrate hot melt type coating is being used as a stop-off in the plating of aircraft crank shafts with a resultant cost reduction of 50% over other methods. Much of this saving is due to the ability to remelt and reuse the coating material 29 times, adding only 25% or less new compound each time.

Whether or not a strippable coating can be used to advantage in any particular application depends largely on whether the resultant savings would be sufficient to justify its adoption. Thus, the cost of the strip-coating material plus the cost of applying and removing it must be weighed against the probable savings from scrap reduction and from lower processing and finishing costs resulting through its use.

It is difficult to give specific cost figures because there are so many variables, and the conditions of use vary considerably for different applications. In addition, there is a wide variance between manufacturers as to the coverage possible with the various type coatings.

However, in conclusion, perhaps a brief survey of the price of strip coat materials will give some indication of the cost of using these coatings. The cost per gallon of water dispersion types in general runs higher than that of solvent types; however, the solids content in the water dispersions is higher and gives greater coverage. So, the cost per square foot of coverage of these two types, in general, is fairly close, with the water dispersions probably being the cheaper of the two. The cost of solvent type coatings runs from approximately $3.50 to $4.25 per gal., and water dispersion types from $5.50 to $6.25 per gal. Based on these rough prices and on the approximate coverage figures for a 0.003-in. film thickness, cited in this article, the cost of water dispersion and solvent types strippable coatings runs somewhere between 2 and 3½c per sq. ft. of coverage.

The hot-melt type coatings are supplied in solid form and the cost ranges from as low as 40c per lb. up to 60c per lb. The hot melts are seldom used on flat sheets and coverage figures for specific film thickness were not available; so only a very rough calculation of the cost per sq. ft. of coverage could be made. The cost is approximately 10 to 15c per sq. ft. of coverage. It should be remembered that in the case of the butyrate type hot melt, this figure would be reduced considerably in some applications because the material can be used over and over again.

The development work on strippable coatings is by no means completed, nor has their field of usefulness in the metalworking industries been fully explored. Some manufacturers of these coatings believe that through proper use of strip coatings it will be possible to reduce the pressures required in drawing and pressing operations. Work along these lines is now in progress and the future should see some useful new developments.

Acknowledgement

We wish to thank the following manufacturers of strippable plastic coatings, who supplied much of the information contained in this article, for their valuable assistance:

Better Finishes & Coatings, Inc.
Ernst Bischoff Co., Inc.
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R. M. Hollingshead Corp.
Naugatuck Chemical Div., U. S. Rubber Co.
Seal-Peel, Inc.
Seibert Varnish Co.
Spraylat Corp.

Through oxygen activation the same salt bath can be used for both cyaniding and carburizing. The new bath permits close control of case depth, rapid carburization and easy cleaning of parts after quenching. Oxygen is used during carburizing but the gas is not supplied when the bath is used for cyaniding.

One Salt Bath for Both Carburizing and Cyaniding

by **FRANK STEIGERWALD,** *Michigan Steel Processing Co.*

IN STEEL TECHNOLOGY carbon added to the surface layers of suitable grades of low carbon steel gives these outer layers the hardening properties of steels of higher carbon content. By this means a low cost material can frequently be given the essential properties of a more expensive one. The combination of hard, wear-resisting case and relatively soft, tough core makes the resulting material more valuable for many applications than either the high or low carbon steel would be.

This desirable result can be achieved by pack carburizing, by salt bath treatment, or by gas carburizing. Pack carburizing is the simplest method in point of equipment required, but is also the most time-consuming and gives the most erratic results. Gas carburizing produces a remarkably even case of controllable depth, but equipment costs are high and the time required is somewhat longer than the commercial heat treater would wish.

Carburizing in molten salt baths of various types has been a standard practice of many years, but it, too, has presented numerous difficulties. Early baths of this type have used sodium cyanide as the active carburizing agent and it is still one of the most useful of the molten salts for carbon enrichment of steel. Unfortunately, the case obtained by "cyaniding" is not a true carburized case. It seems to be a mixture of carbon enrichment and nitriding of the surface. In

Oxygen activated salt requires only a small quantity of simple equipment to permit its use in any salt furnace.

addition, the composition of the bath changes as the bath is used and the rate of change is not accurately predictable. As a result of its drawbacks, cyaniding has fallen into some disfavor as a process for precision heat treatment of steel.

Nature of the New Salt Bath

A recent development in cyanide baths seems to offer the possibility of overcoming most of these disadvantages and, at the same time, of improving the quality of the work. In service at Michigan Steel Processing Co. for more than eight months, it has given excellent results in the exacting schedule of the commercial heat treater's shop. It is easily controlled, and costs of operation for a wide range of parts have averaged slightly lower than those with other types of salt baths.

The distinctive features of the new salt bath, sold by Park Chemical Co., are gas activation of the bath, and complete water solubility of the salt adhering to the work. Most of the activated baths used heretofore have depended on the use of salts of barium, calcium or strontium as the activating material. These salts produce compounds in the bath that are insoluble in water and difficult to remove from heat-treated parts. Cleaning difficulties are eliminated by the new salt bath, in which the adhering salt is readily soluble in

Shown here is SAE 8620 steel carburized for 2 hr. at 1600 F in an oxygen activated salt bath. (Magnification 100X.)

hot water. If oil quenching has been used, a little commercial cleaner added to the water wash will hasten solution.

The salt bath is of the cyanide type, but the case produced is a true carburized case. Activation of the bath with oxygen gas is responsible for the difference. The same bath can be used for both carburizing and cyaniding, serving the former purpose one day when operating with the use of the gas activating agent and the latter the following day without the gas. It melts at 1150 F and works well within the range of 1300 F to 1750 F. The most effective temperatures for operation are between 1500 F and 1700 F.

The bath is usually operated at 1700 F for commercial work. This temperature gives rapid carburization without danger of damage to the work. Oxygen gas is bubbled slowly through the molten salt, feeding in just enough to permit a slight evolution. A needle valve and rotameter help gage the quantity of gas required. The oxygen is carried below the surface of the salt in an ordinary tube, about ¼-in. in dia., and without any provision for stirring. A copper tube is used in the installation at Michigan Steel Processing Co., but an iron tube would probably be just as satisfactory. The tube is inserted in the bath and the gas is bubbled through only when work is about to be put into the bath. If the flow of gas should be accidentally cut off after the bath is in operation, no harm will result as the bath remains effective for 3 to 4 hr. after activation. The bath can stand in the molten condition for several hours without the gas.

Cyanide content of the molten salt must be maintained at above 15% and a daily replenishment schedule is advisable. While the schedule need not be followed rigidly, addition of about 5 to 10% of the weight of the bath is suggested. This amount will also maintain the carbon cover over the bath while in service. Additional carbon can be applied to the bath if necessary, but the incorporated cover will be found adequate for most service conditions.

Pots for the bath can be of pressed or cast steel, or of any of the alloys now widely used for salt baths. Use of ceramic pots and ceramic-lined furnaces is not advised unless these ceramics have been found to be suitable for use with liquid carburizing salts.

When operated at 1700 F a case of about 0.015 in. is produced during the first hour of operation. Two hours will produce a thickness of about 0.025 in., and each succeeding hour will increase the depth of case about 0.005 in. A 1/32-in. thickness is produced within 3 hr.

The gas fed into the bath dissolves readily in the molten salts, so that any gas bubbling through the bath is an excess. Good operation, therefore, requires that the rate of feeding the gas be such that only a small amount will bubble out.

Cleaning Quenched Parts

When the work is removed from the bath no special cleaning is required if the heat treating procedure includes a water quench. As with most salt bath work, the steam explosion incident to water quenching of the heated piece will remove practically all the adhering salt. Oil quenching with the new soluble salt does not require the soluble oils sometimes used for salt bath quenching. In fact, such oils are not entirely satisfactory. While ordinary hot water washing will remove all adhering salt without difficulty, addition of a little sodium orthosilicate or trisodium phosphate, or of any commercial cleaner of the alkaline type, will hasten the washing.

Use of stop-offs, such as copper plate, to obtain noncarburized areas on the surface of the work, is not recommended.

Care must be taken to maintain a carbon cover over the bath sufficiently heavy to protect the bath at all times. Excessive flow of gas will tend to displace the cover and should be avoided for this reason as well as from the standpoint of economy.

The new flux on the left end of test bar wets well, inducing free flow of the solder drop. Standard flux (right) does not have this spreading quality.

New Flux Makes Easier the Soldering of Zinc-Coated Parts

NEW MATERIAL PREVIEW

One reason for the less widespread use of zinc-coated parts in small assemblies is the difficulty of soldering on zinc, particularly zinc treated by passivating processes. The good wetting action of a new, non-corrosive flux results in strong joints on such zinc coatings.

The satisfactory soldering of zinc-coated parts is difficult, but the problem is further complicated when the zinc coating is given a passivating treatment such as is provided by Luster-On and similar materials. Bright dips are needed to add to the attractiveness and corrosion resistance of the zinc surfaces.

Now radio manufacturers and others using zinc-coated parts which must be soldered have available a flux which promises effective bonds which can be achieved without difficulty. The flux, known as Never-Sever, was developed and is being marketed by Chemical Corp., Springfield, Mass. The flux is specifically designed for use on passivated zinc surfaces, but is equally effective on untreated zinc or copper, resulting in a tight, enduring bond.

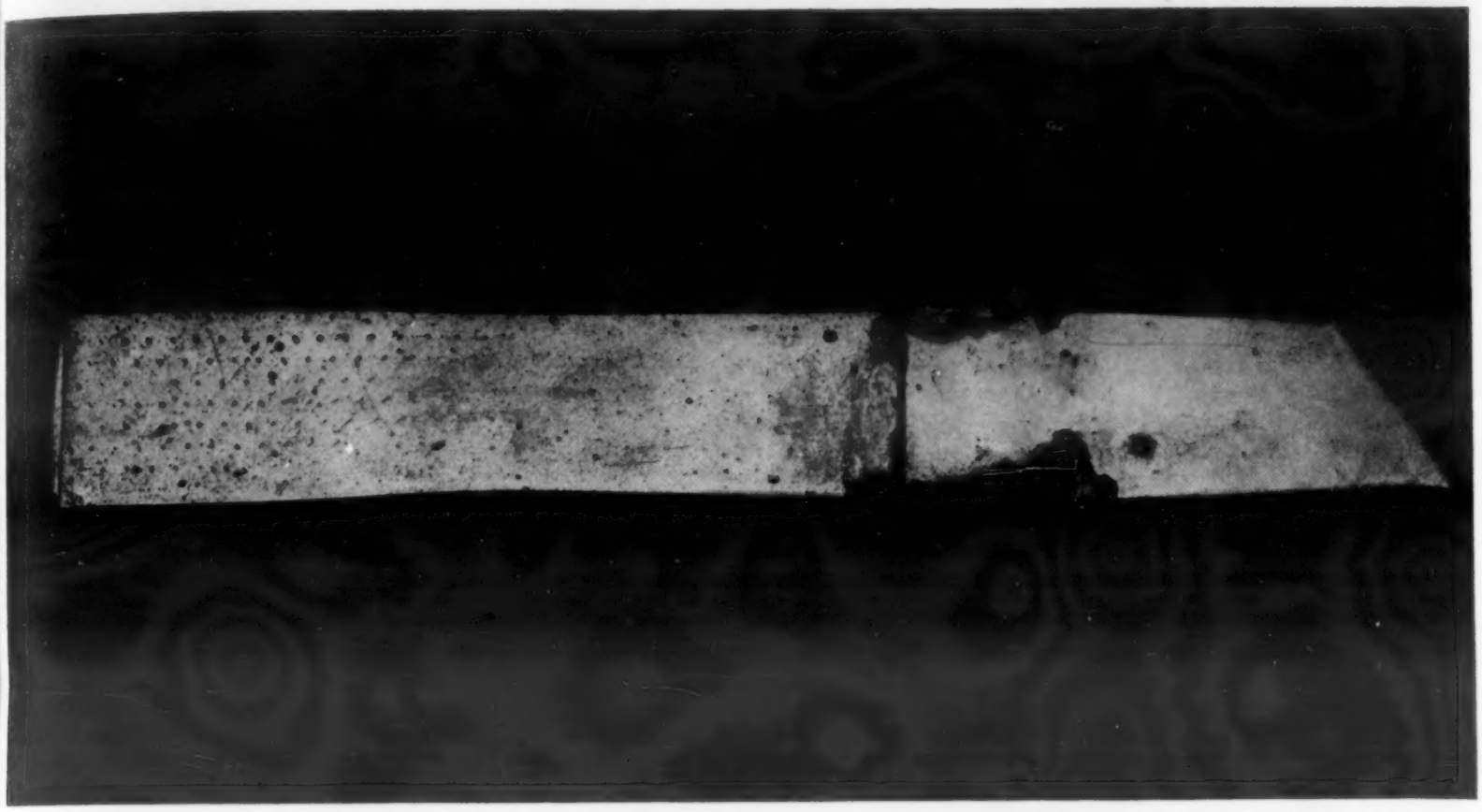
Field and independent laboratory tests on the new flux covered surface wetting, or spreading, ability, shear strength, humidity and salt spray corrosion, and wire adhesion.

On shear tests, an average pull of 1857 psi. was required to break the joint made between two pieces of passivated zinc-plated steel, using Never-Sever flux and 60-40 solder. In some cases the overlap on 1⅛-in. strips was ½ in., in others a 1⅛-in. square. These results represent an increased strength of over 32% above the 1401 psi. average when joints were soldered with a standard zinc chloride flux. In some cases 0.040 steel strips 1⅛-in. wide were deformed and elongated or broken before the solder bond failed.

Pieces of 0.022 copper wire were looped and soldered to Luster-On treated strips using the new flux. On pull tests the wires pulled from the solder without loosening the solder from the base metal.

Surface wetting and solder spreading ability of the new flux are said to be excellent. Tests showed an application Never-Sever flux to spread three or four times as far as the standard flux, and a drop of solder did likewise.

In salt-spray atmospheres excessive white corrosion products were absent on areas where excess flux re-



Steel 0.040-in. thick and 1⅛-in. wide joined with 60-40 solder, using Never-Sever flux, is badly distorted without pulling apart at the joint.

mained. Extensive field tests reveal no corrosion from the flux. The passivating treatment, of course, inhibits corrosion of the zinc surface.

Methods of Application

Never-Sever flux is supposed to be applied in small quantities and almost completely sublimes or evaporates at soldering temperatures.

It should be noted that the soldering temperature for zinc is somewhat higher than the temperatures for cadmium or tin. Tin melts at 231.9 C (449 F), cadmium at 320.9 C (609.6 F) and zinc at 419.4 C (787 F). It is probable that some alloying between the base metal and the solder takes place in each case, which accounts for the need for more heat to procure a permanent joint on the zinc.

The wetting action of the flux on both copper and zinc insures a good spread of solder on the joint area, making it ideal for electrical connections.

The use of passivated zinc plate rather than cadmium plating results in a substantial saving in material costs. A cost study made recently shows savings on the former over the latter of 50% or more. Since soldering is now practical these savings can be extended to many products including electrical parts for radios, and air conditioning and refrigeration equipment, hardware, hand tools and automotive parts.

Wire solder laid between two passivated zinc plates, at acute angle, melts when heat is applied and creeps onto surface wet by the new flux. (Cross section magnified 10X.)

The holes in these brass aircraft motor parts are punched and shaved on a press. The center hole is held to a 0.0002-in. tolerance.

Hole Piercing and Stamping in One Operation

by **ERNEST C. MORSE,** *Lockhart International, Inc.*

PIERCING HOLES WITH DIAMETERS less than the thickness of the blank, or with tolerances under 0.001 in., and piercing holes at the same time as blanking and before forming widens the applications of stamping techniques. Interchangeability as well as lower costs of mass produced parts containing many holes have frequently been achieved through collaboration between designers and stamping production engineers. Interchangeability is often difficult to achieve when many holes in a single complicated shaped piece are drilled or punched individually.

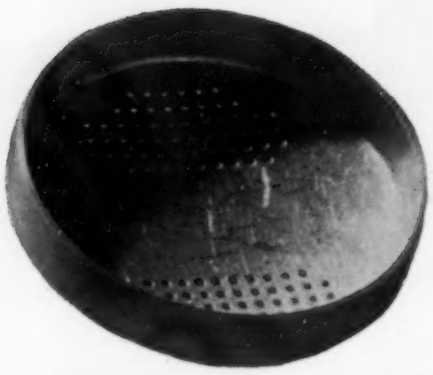
Round or shaped holes are today being successfully pierced in various metals on punch presses by stampers. They vary in size from 1/32 in. to several inches in diameter, and in many instances the diameter of the holes is only a fraction of the thickness of the metal pierced. In some instances as many as 400 holes are being pierced in a single, comparatively small stamping.

Aluminum, brass, nickel, stainless, regular and high strength steels—in fact, all types of metals used by stampers—can be pierced successfully on presses using tools and dies of proper design. Location of the holes with regard to key reference lines can be held to very close tolerances. Tolerances relating to the dimensions of the hole itself are frequently kept within 0.001 in., and in some instances to even closer tolerances.

It is important that pressed metal engineers cooperate in the design of the part to be pierced in order that tool designs and press operations can be simplified as far as possible. Tool design for piercing operations often approaches gage work in accuracy, and allowable tool wear must be kept within close limits. Plastics and rubber have in some instances been combined with steel in the production of piercing punches and dies.

The Pressed Metal Institute has followed with interest recent developments in piercing operations. The illustrations cited were selected by the Institute as examples that would be most helpful in clarifying advances made, and future possibilities in complex piercing techniques.

In the production of one type of airplane carburetor two brass disks ¼-in. thick and 2⅛-in. in dia. are required. In one of these disks the center hole and one other hole are ½-in. in dia. and one hole 3/32-in. in dia. In addition, there are two wedge-shaped holes 9/16-in. long, 5/16-in. across the large end of the wedge and ⅛-in. across the small end. All these holes are punched and shaved on a press, the center holes being held to a diameter tolerance



Pure nickel spinnerettes such as this are used in making rayon yarn. The final press operation is the piercing of 144 1/32-in. holes. (Courtesy: Larson Tool & Stamping Co.)

Holes in all sizes and in varying numbers are being stamped in parts on presses. Sometimes the holes are pierced during forming, but often piercing is done on the unformed blank. All metals suited to stamping can be handled this way and usually with a reduction in production costs. High accuracy is possible.

Twenty holes are pierced in this brass ignition tube which has a wall thickness of 1/16 in. (Courtesy: Larson Tool & Stamping Co.)

Plastics, rubber and steel are combined in this die and punch which pierces a total of 50 holes in 0.025-in. stainless steel. (Courtesy: Lockheed Aircraft Corp.)

Three settings of the aluminum alloy tube were required to obtain the 48 holes. Holes are 3/8-in. in dia. and wall thickness 0.238 in. (Courtesy: Larson Tool and Stamping Co.)

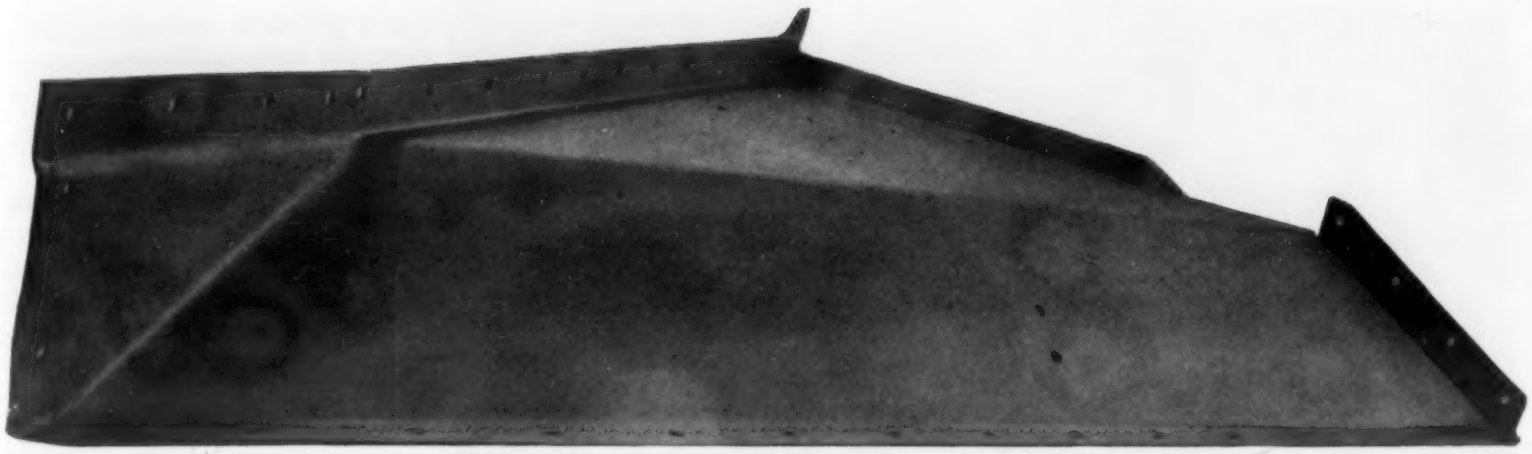
of 0.002-in. The outside circumference of the disk is held to a maximum tolerance of 0.001-in. in the outrun. The complete disk is made by press operations with the counter-sinking of certain holes. Cost of production through the use of stamping techniques was reduced approximately 50%.

One type of rayon yarn employs a pure nickel spinnerette in the process of manufacture. Extreme accuracy in the diameter of the holes is required to assure accurate and identical size of filaments. The spinnerette is approximately 1⅝-in. outside dia. and is made from nickel 0.024-in. thick. It is produced as follows: (1) blank and draw on double action press; (2) trim; (3) pierce 144 holes having a dia. of 1/32-in.; (4) remove all burrs on inside of spinnerette (a combined hand and machine operation).

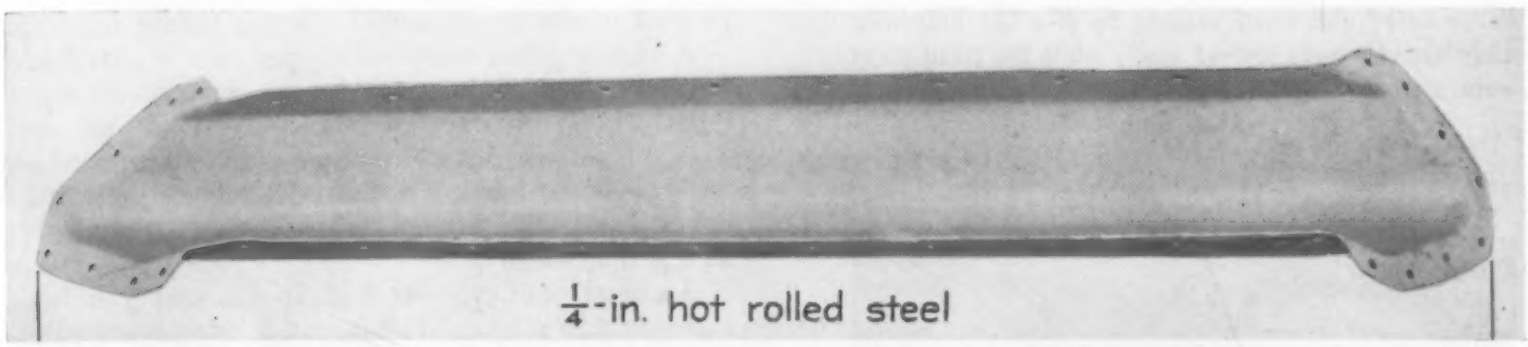
Production of an ignition tube provided an interesting example of piercing operations. The tube, which is made of brass and is approximately 3⅜-in. long and ¼-in. outside dia., and is produced as follows: (1) cut to length and thread one end; (2 and 3) pierce twenty 1/32-in. dia. holes through the tube wall which is 1/16-in. thick; (4) pinch end of tube opposite threads. The inside wall of the finished tube must be absolutely burr-free. Note diameter of the holes with relation to metal thickness in the case of this ignition tube as well as the carburetor disks described above. In both instances the diameter of the holes is only a fraction of the thickness of the metal pierced.

The use of plastic and rubber in the development of piercing dies and punches is growing rapidly in the aircraft industry. For example, an inexpensive piercing die and punch for piercing flat 0.025-in. thick stainless steel has been perfected. The die is made of "Dilecto" with case hardened 1010 steel 0.064-in. thick for the hole dies. It is used for piercing 20 holes 0.125-in. in dia. and 30 holes 0.093-in. in dia. in a sheet 33¾-in. long and 12½-in. wide. Individual rubber strippers are used with each piercing punch. The die made by inexperienced help is easy to handle, being about one-tenth as heavy as an all-steel die. It has been in service for nearly two years. Similar dies have been made for piercing over 500 holes in a single sheet of "Dural" stock.

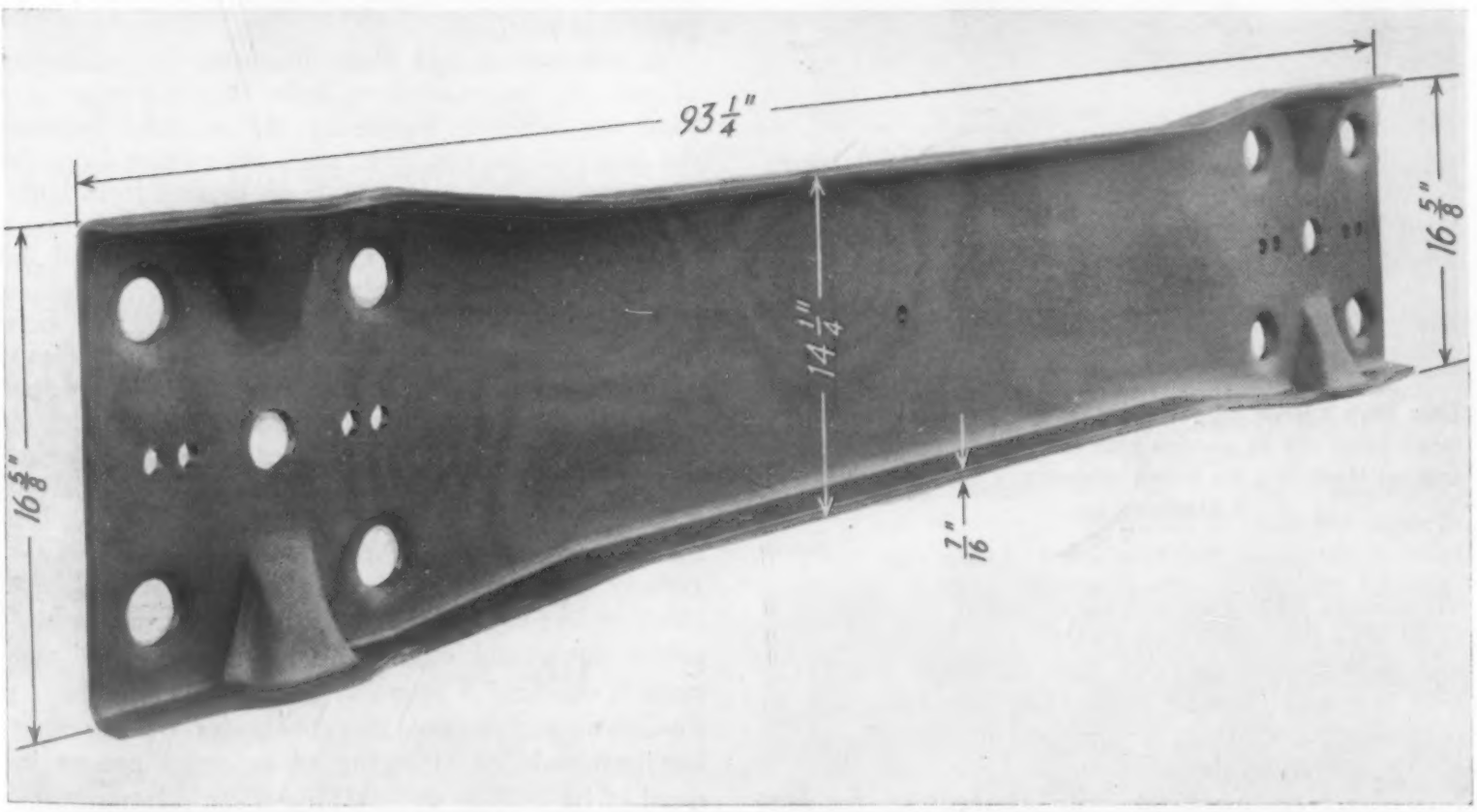
A heavy wall aluminum tube containing 48 holes illustrates an unusual piercing job for a press. It proves that difficult mass production problems can be solved by stamping engineers. This part is made by cutting 2S aluminum alloy hard tempered tubing into 8-in. lengths. This tubing has an O.D. of 1.438-in. and a wall thickness of 0.238-in. The production of the finished tube containing forty-eight ⅜-in. holes involves the following operations: (1) pierce holes on press (three settings of tube required for



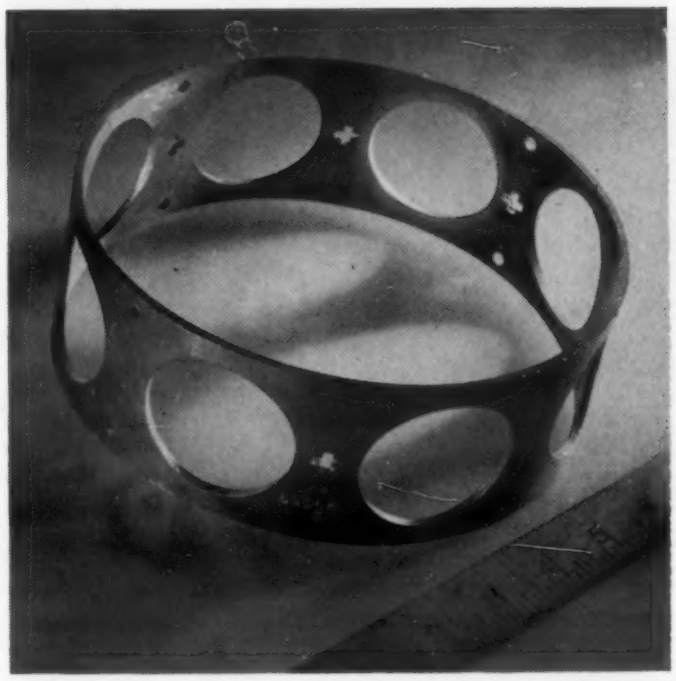
Railroad car hopper plates are blanked and pierced in one operation. This is a difficult layout problem, but reduces assembly problems.



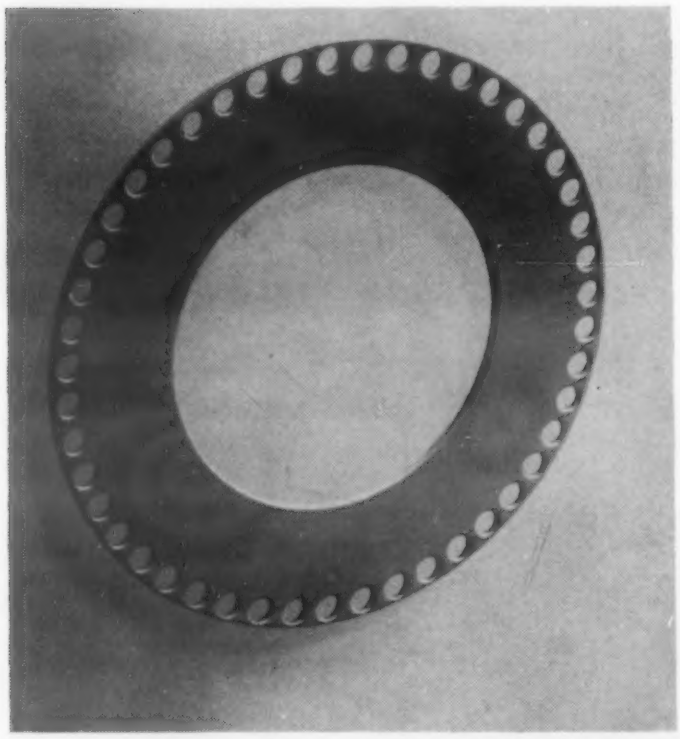
Pierced in the flat before forming, the holes in this hood sheet for hopper cars are all accurately located for assembly.



This spring plank for railroad cars is made of ¼-in. thick hot rolled steel. The holes are pierced during blanking and then the blank is formed. (All illustrations this page courtesy of Parish Pressed Steel Co.)



Large holes and small crosses in this 52S aluminum alloy cylinder were pierced singly while the small holes were pierced in pairs. (Courtesy: Worcester Pressed Steel Co.)



This pure copper motor rotor end plate shows how small holes can be pierced near the edge of a stamping without fracturing the metal. (Courtesy: Larson Tool & Stamping Co.)

48 holes); (2) counter-sink on press all holes both ends; (3) size tube walls to 0.002-in. tolerance. This tolerance applies to both wall thickness and O.D.; (4) face and chamfer ends. Any distortion due to perforating operations is corrected in the subsequent sizing operation described under operation No. 3. This sizing operation not only compensates for mechanical distortion but for any variations in tubing dimensions.

Production of large, complicated, interchangeable stampings with many assembly holes in various planes of the finished stamping can be stepped up and costs reduced by piercing all holes during the blanking operation.

Hopper plates for railroad cars made from ¼-in. hot rolled pickled steel are 46-in. wide and 108-in. long. These plates have 45 holes 11/16-in. in dia., located in seven planes. All these holes are pierced in the flat sheet during the blanking operation. Layout of these holes for proper location after the hopper sheet is formed is difficult. Further, it is essential that holes be absolutely round after the sheet is completed. However, assuming the layout is accurate, all hopper sheets are then identical and interchangeable. Assembly costs are therefore reduced to a minimum.

A longitudinal hood sheet for hopper cars is made from hot rolled steel ¼-in. thick and has an overall finish length of approximately 122-in. and a width of 19⅜-in. The thirty-six 11/16-in. dia. holes are all pierced in one operation in the flat before forming.

A spring plank for steel hopper cars is also made from ¼-in. thick hot rolled steel. It contains eight holes 2¼-in in dia., two holes 2-in. in dia. and 21-13/16-in. in dia. These holes are all pierced in the rectangular blank. The finished plank 93¼-in. long by 16⅜-in. wide is completely formed in the press in one operation.

An aluminum cylinder 8-in. in dia. and 3-in. high is made from 52S 0.115-in. thick aluminum alloy. This cylinder has eight 2-in. round holes, eight ¼-in. round holes and six ⅜-in. holes in the form of a cross. Operations are as follows: (1) blank (dia. approximately 13½-in); (2) draw; (3) cut out bottom; (4) machine edges; (5) pierce holes. The eight large circular holes are pierced singly. The six small crosses are pierced singly, the eight small holes being pierced in pairs.

A motor rotor end plate illustrates the possibility of piercing many accurate holes near the edge of a stamping without fracturing the material between the hole and the rim. The plate must come from the press absolutely flat and the holes be free from burrs. The plate shown in the illustration is made of pure copper 0.060-in. thick. The O.D. is 3⅝-in. and the 48 holes are approximately 5/32-in. in dia. Attention is called to the thinness of material which is only 0.030-in. between the hole and outside circumference of the disk. Progressive dies and "French" stripper are used. The punches are made of oil hardening steel and more than 35,000 pieces are produced without tool grinding.

Designers of equipment for the home as well as many industries, including chemical, textile, rayon, railway equipment, airplane, food, electrical and cleaning, are eagerly seeking ways and means to keep prices down and quality up. Interchangeability of parts is essential if assembly costs are to be kept at a minimum and stampings provide for the necessary interchangeability. Piercing of holes on presses instead of by drilling or punching is an important field where stampings have demonstrated their value in design and production.

A crucible of molten magnesium is being removed from the melting furnace.

The Ignition of Magnesium Alloys During Heat-Treatment

by **C. B. WILLMORE and W. S. PETERSON,** *Process Metallurgy Div., Aluminum Research Laboratories, Aluminum Co. of America*

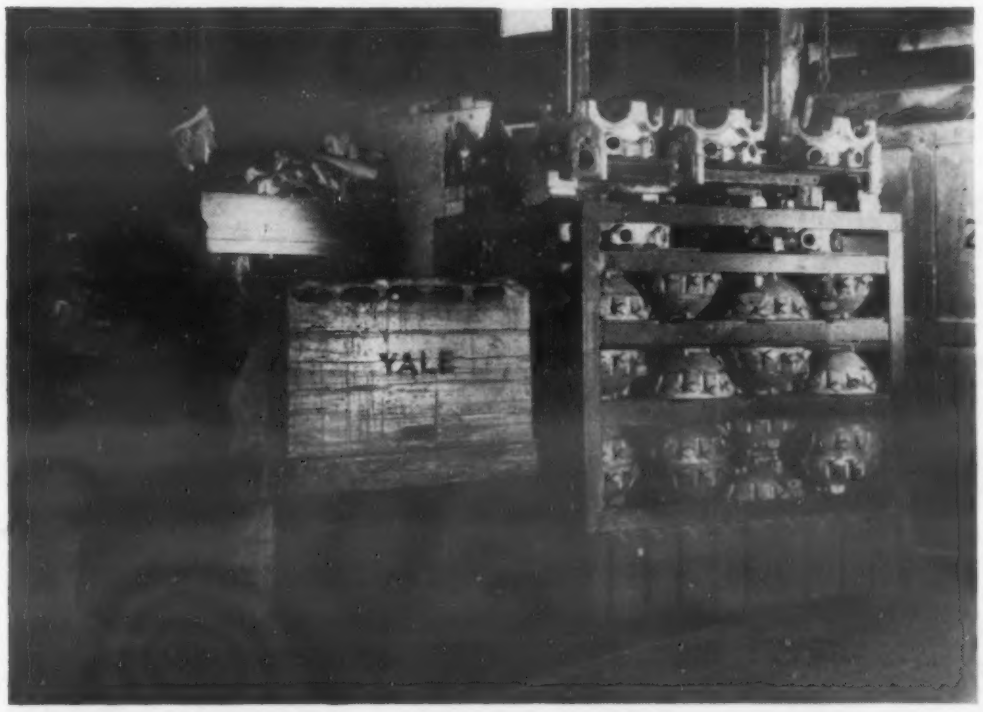
Sometimes magnesium alloys are known to ignite during heating at supposedly safe temperatures so exhaustive tests have been conducted to determine why the ignition point was lowered. Fire hazards result from accidental contact with materials which form low melting alloys, slivers, burrs, sharp edges, and often humidity.

SERIOUS FIRES HAVE OCCURRED during the heat-treatment of magnesium alloys. To determine the effects of factors that might influence the ignition of magnesium, a series of ignition point tests were conducted on two common magnesium alloys.

The results of these tests showed that the ignition temperature of sandcast AM265 alloy in air decreased by increased moisture content in the furnace atmosphere, rate of air flow and rate of heating. The ignition temperature of extruded AM3S alloy is practically independent of air velocity and rate of heating but is lowered by increased moisture content.

Fires can occur with massive magnesium alloy pieces at furnace temperatures below the melting point of the nominal alloy composition. Accidental contact of magnesium alloys with other metals, such as zinc, cadmium and aluminum, under conditions which lead to local formation of low melting magnesium alloys may also result in fires. Slivers, sharp edges or other very thin sections, which may be subjected to local overheating from the accidental presence of comparatively small amounts of organic combustibles are additional fire hazards.

During the pouring of magnesium sand castings, sulfur is shaken on the molten metal to prevent burning.



Fire hazards are lower with massive magnesium parts such as these aircraft engine castings.

Test Conditions

Ignition tests were made on sandcast AM265 and extruded AM3S magnesium alloys using rectangular specimens with dimensions of approximately 2½ by 1½ by ½ in. and on AM3S rolled sheet 0.064 to 0.100-in. thick by 3 in. sq. Tests of the effects of the moisture content of air at low and medium air velocities were made in an iron retort fitted with a bolted head. The head accommodated an inlet tube which led to within 2 in. of the rear wall of the retort and an exit tube with an opening in the head itself. The air in traveling nearly the entire length of the retort in the inlet tube was brought to the retort atmosphere temperature before passing over the specimens. The retort, surrounded by heavy plates of aluminum to effect more uniform temperature distribution, was heated in an electric muffle furnace having automatic temperature control. The specimens, supported on bare iron racks, were placed in a selected area of the retort where the temperature was uniform within ±3 F.

Tests at higher air velocity, corresponding to commercial heat treating practice, were made in a Homo furnace in which the linear air velocity was about 2100 ft. per min. The direction of air flow was reversed in this furnace every 60 sec. Because the air in the Homo furnace was recirculated and blown over the heating elements, it was, at times, at a slightly higher temperature than the specimens. Tests on magnesium specimens in the presence of inflammable organic matter were made in an electrically heated crucible furnace.

The effect of contact with other metals was usually

tested by fastening the metal under test to the magnesium alloy specimen with iron bolts. In other instances, the second metal was threaded and screwed into the magnesium. When the second metal was expected to melt at the testing temperature, it was placed in a vertical depression drilled in the magnesium.

The temperatures of the magnesium test pieces were measured by individual fine wire thermocouples maintained in direct contact with the surfaces of sheet specimens or embedded in small holes in the cast specimens. Separate thermocouples were used to measure the furnace atmosphere temperature in the vicinity of the specimens. Ignition temperatures were determined by plotting the differential between the specimen temperature and the furnace atmosphere temperature and noting the temperature at which this differential showed a sustained rapid change from a previously constant value.

The Ignition of Sand Cast AM265 Alloy

The ignition temperatures of sandcast AM265 alloy under different furnace atmosphere conditions and heating rates are given in Table 1. The presence of considerable moisture at a given flow rate decreased the ignition temperature 65 to 75 F below that in dry air. An increase of linear velocity of air from 0.9 to 14 ft. per min. over the specimens decreased the ignition temperatures roughly 40 F in both moist and dry air.

In the Homo furnace, with air velocity of 2100 ft. per min. and an average humidity of 4 grains per cu. ft., the ignition temperature was approximately 840 F when the step-wise heating procedure was followed, but it was decreased to approximately 805 F when heating was rapid.

The presence of 0.02 to 0.04% calcium and 0.0002% beryllium in the AM265 alloy increased the ignition temperature by only 25 to 35 F, although the resistance to oxidation during ordinary heat treatment is greatly increased by these additions.

Many different substances were heated in contact with sandcast AM265 alloy in the Homo furnace in air containing 4 to 6 grains water per cu. ft. In these tests the specimens were heat-treated for periods of 24 hr. at temperatures ranging from 650 to 810 F. Iron, stainless steel, chromium-plated steel, yellow brass and paint primers had no appreciable effect on the sandcast AM265 alloy at the solution heat treatment temperature of 730 F. Contact with tin alloys at 730 F caused only slight alloying and oxidation without ignition. A casting impregnated with sodium silicate showed only slight spotting from exudation of the silicate. Contact with aluminum alloys had no appreciable effect on AM265 at 730 F but usually caused ignition at temperatures about 820 F, presumably because of formation of the liquid aluminum-magnesium eutectic alloy.

Contact with zinc alloys, galvanized iron, pure cadmium and cadmium-base solders caused extensive oxidation of AM265 alloy at 700 F and usually caused ignition at 730 F. However, the presence of 0.0002% beryllium and 0.02 to 0.04% calcium in the AM265 alloy prevented ignition at 730 F during contact with cadmium-base solder. Contact with lead caused alloying and considerable oxidation without burning at 650 F and 730 F but ignition did occur in a test in which the furance temperature was held at 810 F.

It was presumed that the lowering of ignition temperature following contact with zinc resulted from the formation of liquid magnesium-zinc or magnesium-zinc-aluminum eutectic or peritectic alloys. That these alloys have low ignition temperatures was confirmed by tests on specimens consisting principally of the 54 zinc-46% magnesium eutectic and of the 48.5 magnesium-38 zinc-13.5% aluminum peritectic composition, which have melting points of 646 F and 680 F, respectively. Both of these alloys ignited readily at 730 F. It is believed that the effect of rapid heating in lowering the ignition temperature of AM265 alloy results from the presence of small amounts of one of these constituents which do not have time to diffuse into the solid grains before its ignition temperature is reached.

TABLE 1—The Effects of Air Velocity, Humidity and Heating Rate on the Ignition Temperature of Sandcast AM265 Magnesium Alloy

Heating Schedule*	1	1	1	1	1	2
Air Velocity, Ft. per Min.	0.9	0.9	14	14	2100	2100
Humidity, Gr. per Cu. Ft.	0.02	9.0	0.02	9.0	4.0	4.0
Ignition Temperature, F	955 ±5	880 ±6	910 ±4	843 ±5	840 ±10	805 ±10

* Schedule 1—Room temperature to 640 F in 2 hr., 640 F for 2 hr., then 45 F rise per hr.

Schedule 2—Room temperature to 800 F in 2 hr.

TABLE 2—The Effects of Foreign Metal Contacts on the Ignition of Sandcast AM265 Magnesium Alloy

Heating Schedule	Room temperature to 640 F in 2 hr., 640 F for 2 hr., then 45 F rise per hr. to desired temp. level				
Air Velocity	2100 ft. per min.				
Humidity	4 to 6 grains per cu. ft.				
Metal Contacting AM265	none	Zn alloy*	Cd alloy**	Pb	Al
Ignition Temperature, F	840 ±10	700-730	700-730	780-810	820 ±3

* Zinc die casting alloy: 96 zinc = 4% aluminum.

** Cadmium base solder: 90 cadmium = 10% zinc.

Ignition of AM3S Alloy

The ignition temperature of AM3S alloy was found to be practically independent of air velocity and rate

TABLE 3—The Effects of Air Velocity and Humidity on the Ignition Temperature of AM3S Magnesium Alloy

Heating Schedule	Room temp. to 800 F in 2 hr., then 45 F rise per hr.			
Alloy Form	Sheet	Sheet	Block	Block
Calcium Content, %	0.30	0.26	0.07	0.07
Air Velocity, Ft. per Min.	0	2100	14	14
Humidity, Gr. per Cu. Ft.	4	6	0.02	9.0
Ignition Temperature, F	1175 ±5	1167 ±2	1187 ±9	1149 ±6

of heating. In dry air, the ignition temperature was 1187 ± 9 F; the presence of nine grains moisture per cu. ft. of air decreased this to 1149 ± 6 F. It is believed that the ignition temperature of AM3S alloy is less sensitive to atmospheric conditions than that of AM265 alloy because AM3S alloy does not contain low melting constituents such as are found in sand-cast AM265 alloy. It is to be pointed out that the ignition temperature of 1149 ± 6 F determined in air containing nine grains moisture per cu. ft. is below the usually accepted melting range of 1198 F for AM3S alloy. Analysis of the AM3S block specimens showed 1.56 manganese, 0.07 calcium, <0.01 aluminum, 0.01 iron, 0.01 silicon, <0.01 copper, <0.002% nickel.

AM3S alloy sheet is usually annealed at about 800 F, but the temperature is sometimes carried as high as 850 F to facilitate the removal of lubricants. Fires are not uncommon in this annealing range. In one such fire, the temperature-log of the furnace showed definitely that the fire started when the furnace temperature was between 680 and 700 F.

The effect of contact with aluminum on AM3S sheet during heat treatment was determined. Specimens consisting of commercial AM3S sheet bolted to the aluminum alloys, 2S-O sheet, 24S-T sheet, 75S-T sheet and 2S foil, were heated in the Homo furnace in air containing 4 to 6 grains water per cu. ft. In the range of 740 to 810 F this contact resulted in a slight welding with negligible melting and oxidation. At 817 to 820 F, considerable melting and oxidation occurred. At temperatures above 825 F contact between aluminum alloys and AM3S alloy resulted in fire. If operating conditions require that a furnace be used interchangeably for aluminum and magnesium, the annealing temperature for AM3S should be lowered to 810 F or less to prevent possible fire by contact with residual aluminum particles.

The presence of fine slivers or ragged edges is common with in-process AM3S sheet. Tests showed that the presence of these slivers did not lower the ignition temperature appreciably but increased the susceptibility of the sheet to minor ignition conditions, such as small flames from bits of burning organic matter.

In tests duplicating the normal rate of temperature rise in annealing (room temperature to 800 F in about 2 hr.) it was found that pieces of cotton waste, cotton gloves, leather mitts and small pieces of wood in close proximity to slivers on the AM3S sheet merely carbonized and "glowed" to ash during the heating-up period without igniting the magnesium. Oil and grease, originally present on the cold sheet, distilled off harmlessly. It appears, therefore, that the presence of these materials in small amounts under the conditions above does not present a serious hazard although every effort should be made to keep the heat treating furnace free of extraneous materials.

Close proximity of slivers to furnace heating elements also present a fire hazard. Heating element temperatures, in many cases, are above the ignition temperature of the magnesium alloy. With massive magnesium, excessive heat would be conducted away harmlessly from any point too close to the heating elements, but if a fine sliver or sharp edge were in this position, conduction might not be sufficiently rapid to prevent ignition of the exposed portion of the sliver. No fires have been traced to this cause but the possibility should not be ignored in the annealing of magnesium sheet.

Mechanism of Ignition of Magnesium Alloys

Previous theories as to the ignition of magnesium have held that melting is a prerequisite to ignition of magnesium alloys and a close correlation was found between melting and burning in this investigation. However, it was found that, under certain conditions, exposure to furnace atmosphere temperatures below the apparent melting point resulted in ignition. Ignition in this case appears to be a two-step process consisting of a relatively slow initial oxidation, which is (an exothermic reaction) followed by melting and very rapid oxidation. The second step of burning with glowing or flaming of the magnesium alloy will occur only if the amount of heat generated in the initial oxidation is sufficient to cause melting of some portion of the alloy. The temperature at which the original oxidation leads to burning is dependent upon composition of the alloy, moisture content and in some cases velocity of the air over the alloy.

Although burning of magnesium in the sense of oxidation with attendant emission of light may take place only after melting, the original temperature condition responsible for ignition may be below the melting point of the alloy. It is dangerous to use melting point alone as a guide in setting up limits of safe heat treating practice for magnesium alloys. The conditions which may influence ignition of magnesium alloys are complex and often difficult to determine and analyze.

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Large nickel-clad steel tanks have been successfully welded by special submerged melt techniques.

Joining Corrosion-Resistant Alloys by Submerged Melt Welding

by **R. J. ANDERSON,** *Manager, Unionmelt Service, Dominion Oxygen Co., and*
H. J. ROBERTS, *Unionmelt Process Engineer, Linde Air Products Co.*

High-speed welding of corrosion- and heat-resistant alloys by the submerged melt process is highly satisfactory, using special techniques and suitable rods. The value of the process to high-cost materials is high, due to close control over weld alloy content.

THE INHERENT SOUNDNESS AND UNIFORMITY of submerged melt welding is possibly of greater advantage in welding corrosion resistant alloys than in lower cost materials because of the values involved. This, and the fact that close control is obtained of the alloy content of the resultant weld, makes submerged melt welding valuable when it can be applied.

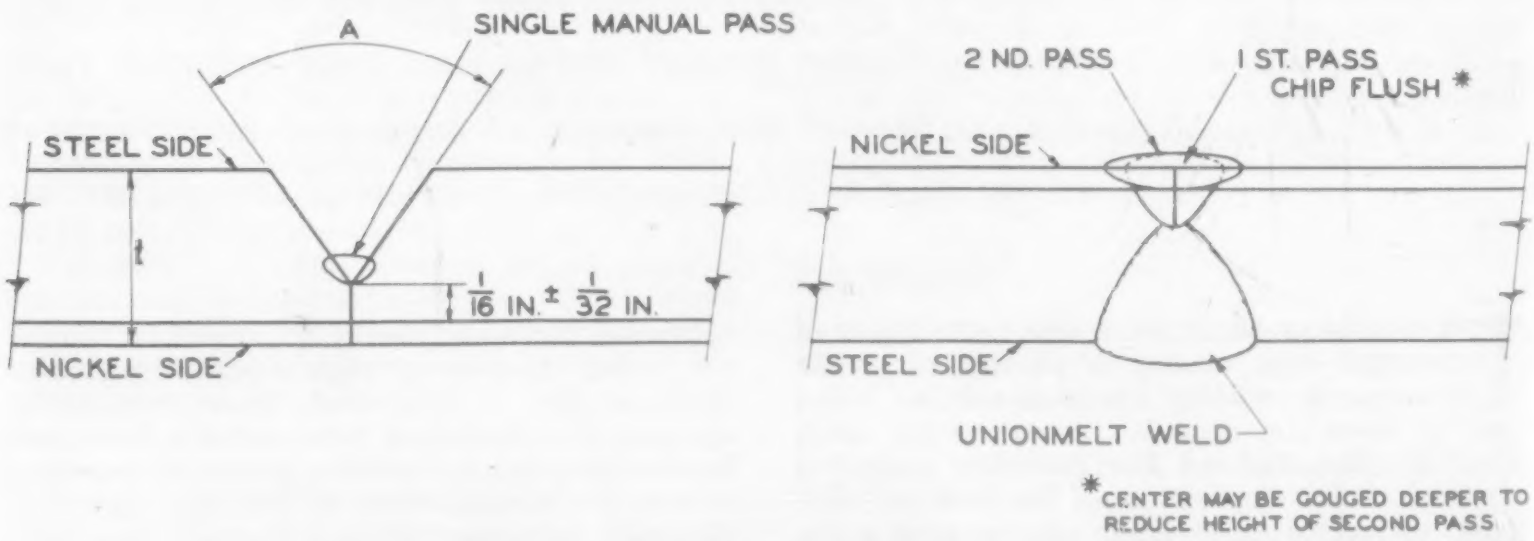
Stainless steels can usually be welded by using a rod having the same or slightly higher content of chromium than the base metal. There are numerous applications of welding of thin sheets of stainless steel by the submerged melt welding process in the manufacture of containers used by the dairy and food processing industries. Nickel and copper base alloys require welding rods of the same general type as the

Submerged melt welding techniques offer possible improvements in the transportation industry.

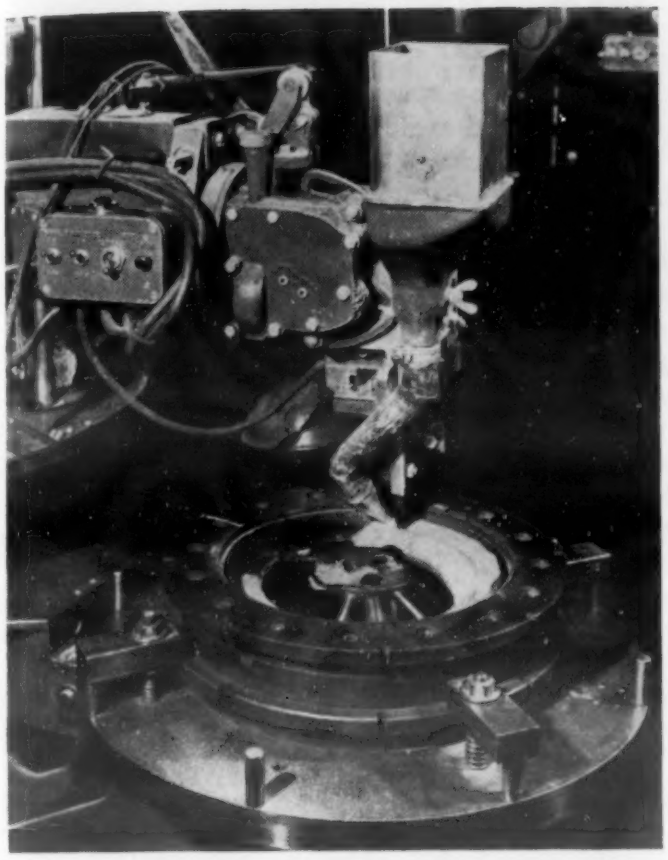
base metal. Special techniques are sometimes required to meet the specifications for the product.

The problems in connection with the welding of corrosion and heat-resistant metals are both physical and chemical. Due to the annealing action, welds in copper and nickel alloys may have low tensile strength. Occasionally the welding action alters the chemical resisting characteristics of the metal. This results in areas that become subject to corrosion while the metal in the adjacent area is not affected. The reasons for the chemical change brought about by the welding action may be due to the loss of alloying elements in the weld metal or the formation of boundaries caused by precipitation of alloying elements.

The granulated welding compositions most commonly used on low carbon steel are not generally the most satisfactory for alloyed materials. It is possible to choose the granulated material that will maintain the alloy content of the material being welded within satisfactory limits. The welding of



Methods used for the welding of nickel-clad steel.



Special holding fixtures are used to adopt the welding of gas turbine wheels by this process.

dissimilar metals, such as clad steels, presents an additional problem in the dilution of the clad surface by the base metal.

While it is usual to choose a welding rod of the same chemical composition range as the parent metal, it has been found advisable sometimes, to use a rod that has a higher percentage of certain alloys than the parent metal. This is to allow for those elements that are lost during the welding process. Columbium and chromium are examples of elements so affected. Special formulas of granular welding composition have been developed to supply alloying elements which may be lost. Special operating procedures have also been developed to give satisfactory results.

Welding Copper-Silicon Alloy

One-half inch copper-silicon plate was welded at 975 amp., 39 v., and at a speed of 20 in. per min. The material was prepared with a 60-deg. vee included angle and a 3/16-in. unbeveled root face. Copper-silicon 1010 rod, 5/16 in. in dia., was used with grade H Union-melt material.

In the free bend test with the top of the weld outside, 72% elongation was obtained with no failure. Back of the weld was bent so that an elongation of 84% was obtained with no failure. Table I gives the tensile properties of longitudinal, all-weld-metal specimens and of transverse sections across the weld. Charpy impact test results on both the plate and the weld metal are also given.

The weld showed higher manganese and lost

Table I—Mechanical Properties of Copper-Silicon Welds

	Yield Point, Psi.	Ultimate, Psi.	Elongation in 2 In., %	Reduction in Area, %
Longitudinal	15,390	47,100	70.6	59.0
Transverse	16,300	46,200	49.3	59.0
Charpy Impact Test				
	Room Temp.		—78 deg. C	—183 deg. C
Plate	83 ft.-lb.		75.5	74.5
Weld Metal	27.7 ft.-lb.		32.7	31.5

silicon, as shown in the following table. It was extremely ductile.

	Si	Mn	Fe
Plate	2.71	0.97	0.35
Rod	2.93	0.93	0.50
Weld	2.50	1.21	0.42

It is expected that further developments will give higher tensile strengths by use of a higher silicon content in the welding rod.

Welding of Nickel and Monel Plate

Satisfactory welds have been made in nickel and Monel metal plates. The plates were prepared with a 60-deg. vee with 3/16-in. unbeveled root face. The first welds were made with grade 80 Unionmelt material and then additional welds were made with grade 20 material.

The first welds in nickel plate made with both grades of material showed some porosity in X-ray examination, because of failure to penetrate the full thickness. Another weld was made with grade 20 material in the nickel using a deeper 60-deg. vee bevelled down to a 1/16-in. nose, and the welding speed was reduced from 18 to 10 in. per min. This change resulted in a wider weld, more thorough penetration, and almost complete absence of porosity. Tests for tensile strength were made on the Monel and nickel. The all weld metal Monel tensile test showed that the weld was approximately 80% of the strength of the plate. The nickel weld had about 70% of the strength of the plate.

Charpy impact tests were made at room temperature, −78 C., and −183 C. There was practically no change in the impact resistance of the Monel samples. The Charpy values were from 40 to 50 ft.-lb. or about one-half the values for the plate. In the nickel weld, two of the specimens gave low values at −183 C. The low value specimens showed pronounced columnar structure and fracture along the center freezing line. Heat-treatment or the use of an alloyed nickel rod (possibly with manganese) would probably improve the impact values of nickel welds at −183 C.

Welding of Nickel Clad Steel

In the welding of nickel-clad steel, either of two methods can be used. One method insures freedom from contamination of the steel weld by the nickel. A manual bead is first laid down in the vee. A Unionmelt pass is then made on the steel side penetrating into the hand pass. A Unionmelt weld is then made on the nickel side with nickel rod, the bead is chipped flush, and a second bead laid down. In this manner the contamination of the nickel deposit can be limited to less than 15% iron. In the other method, the weld is first made on the nickel surface with nickel rod. The second bead is laid down on top of the first and then the main part of the weld made by the Unionmelt method on the steel side.

Special welding techniques were necessary in the Unionmelt welding of nickel-clad steel for tank cars. The tanks were fabricated from ⅜-in. and ½-in. steel, clad with a 0.025-in. nickel surface. All bevels were made by machining. The root faces were butted together tightly and strips tacked across the vee to hold the plates in place. A manual bead was laid down in the vee and a single pass weld was made at 540 amp. on the steel side. The nickel side was then gouged out about 1/16 in. and a nickel deposit made by a manual arc weld.

Welding of the Stainless Alloys

The widest use of submerged melt welding applied to corrosion resistant alloys is on 18:8 stainless steels. Welds have been made in ¾-in., columbium bearing, 18:8 chromium-nickel plate. The angle of the vee was 45 deg. A welding of current of 900 amp. at 40 v., and a welding speed of 12.5 in. per min. were used. The finished weld showed good penetration with a reinforcement of about 3/32 in. There was practically no loss of columbium during the welding. The nitrogen content corresponded to the usual amount found in these alloys and indicates complete protection of molten metal. Tensile strength tests showed a yield point of 40,000 psi. and an ultimate strength of 76,450 psi. Corrosion tests indicated that the weld corrosion rate was essentially that of the base metal.

The welding of stainless steel presents no particular problem, except that in type 347 stainless steel sheets, less than ⅛-in. thick, cross cracking is likely to be encountered. A sample stainless steel refrigerator car has recently been completed. The sides of this car are made of 18-gage, Type 304 stainless steel. Type 316, welding rod ⅛-in. dia. was used. The welding current was 325 amp., direct current, reverse polarity at 25 v., and welds were made at speeds of 60- and 90-in. per min. The sheets were first joined by square butt welds. Then welds were made through the sheets into ¼-in. thick mild steel vertical posts on 24 in. centers. Horizontal fillet welds attaching the stainless steel sheet to both the top and bottom sills as well as a vertical fillet weld on each corner sill were then made.

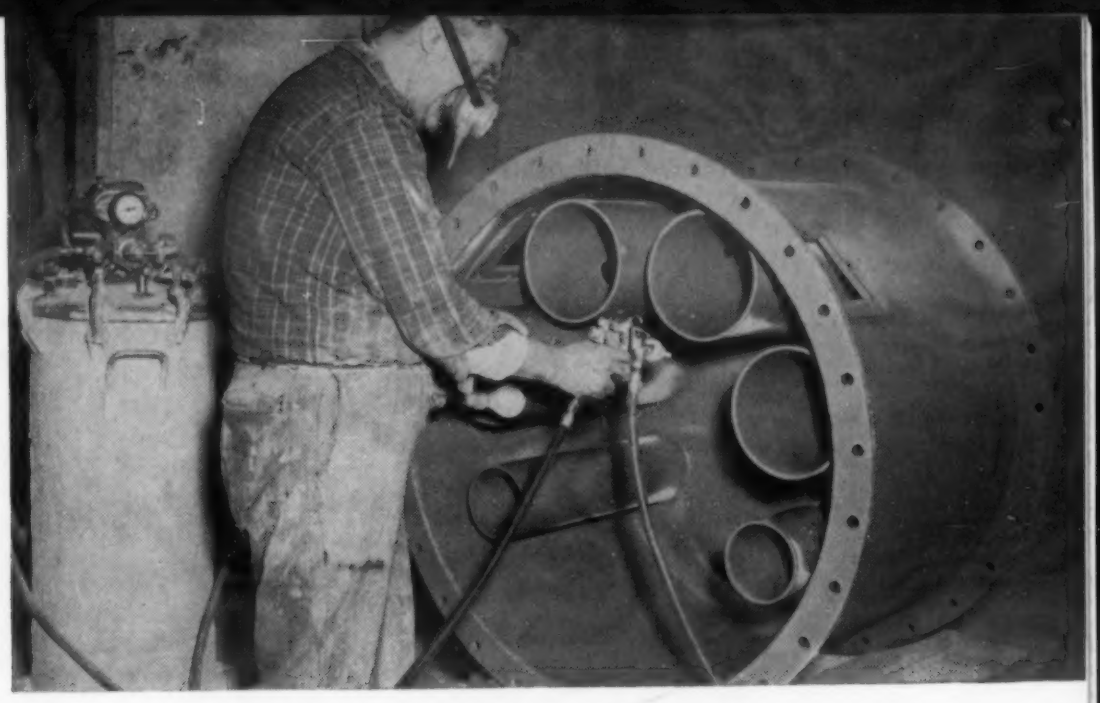
The hand welding of 4 to 6% chromium steel usually requires that the parts be preheated and maintained above 300 deg. F during welding. It has been found that this alloy can be welded with the submerged melt process without preheating and, though preheat may be used as a precautionary measure, the fact that the welding can be completed quickly and without subjecting the welder to undesirable working conditions, makes it advantageous to use this welding process. Plate preparation and welding conditions are practically the same as those used in welding mild steel.

Shown here is a finished weld in a gas turbine wheel.

Welding Heat-Resistant Alloys

In the welding of the heat-resistant alloys, the best known application is the welding of gas turbine wheels. The buckets of the wheels, made of Multimet alloy or Stellite alloys Nos. 21 or 30, are welded to the center hubs usually of 19-9 DL alloy by a double vee weld made in one pass from each side. A special fixture is necessary for clamping these buckets in position during assembly, preheating and welding.

It has been found that the surface of chromium alloy rods for submerged melt welding should be clean and bright to minimize heating when the rod picks up the welding current. The distance from the end of the contact jaws to the welding zone should be short so the rod will not heat when it is carrying the full welding current. Heating of the rod causes the weld to change from its normal contour to a narrower top with a loss of penetration. Because of the high heat and current conductivity of copper and nickel base alloys, the surface of such rods need not be so carefully specified.



A special ceramic coating is being sprayed on a steel section of a submarine silencer. (Courtesy: Finish.)

Types and Characteristics of Modern Porcelain Enamels

by **HAROLD A. KNIGHT,** *News Editor,* MATERIALS & METHODS

PORCELAIN ENAMEL COMBINES the workability of metal with the advantages of glass, providing a smooth, colorful surface that resists wear, corrosion and other destructive forces. Colors, available in a wide range, remain brilliant, and the finish is easily cleaned. It will withstand severe atmospheric and climatic conditions and cannot burn or be affected by ordinary heat, flame, or quick temperature changes.

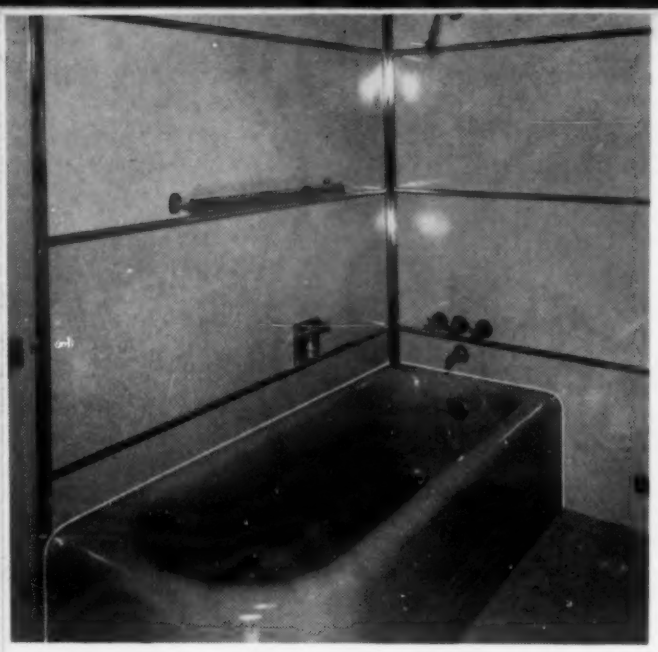
Porcelain enamel, in its older uses for refrigerators, bath tubs, gas ranges and enameled kitchenware, is known most universally. But what is perhaps less known is that it has a host of new uses and applications. The industry has passed through evolution rather than more glamorous revolution. It is one of our important modern engineering materials that has a glowing future. Enamels have materially improved over the past 25 years.

Recent developments in porcelain enamels have resulted in greater opacity in sheets with thinner coatings of ceramic. Present enamels provide more and better colors, better acid resistance and easier forming. Improved base materials have helped to achieve better enameled surfaces.

One of the spectacular modern discoveries was that the Germans coated many parts exposed to high heat in their jet airplanes with porcelain enamel which stood up under temperatures of 1100 F, not on a par of course with the more enduring American jet aircraft. Hence, enamel is not yet, at least, a competitor with our super alloys, containing chromium, nickel, cobalt, molybdenum, etc.

However, porcelain enamel did serve well with the American armed forces such as for coating exhaust pipes of trucks, aircraft and marine mobile equipment. Under sea water exposure it could withstand both high heat and corrosive influences. This suggests that similar uses for peace time equipment would be satisfactory. Among the newer applications are for coating aluminum, for electrical transformer cases on telephone poles, for home hot water tanks, electric stove heating elements and reflector pans.

Architectural porcelain bids fair to be a coming thing because of low cost, bright colors and durable coatings. With it, too, a highly heat resisting finish has been given pots for melting and casting light metal alloys, it being claimed that the life of the pot has been increased from the usual four or five days to several weeks for coated pots. At least two large companies planned to use enamel as both exterior and interior finish on housing: the Andrew J. Higgins Co., New Orleans, and Lustron, Inc., Chicago. Both projects bogged down in their initial form with the collapse of the National Housing Administration. Such homes are too expensive to be constructed as



Porcelain enamel panels are used to provide gleaming walls in this modern bathroom.

single units—they must be mass produced. Porcelain enamel roofing has good prospects, either as corrugated sheets or individual shingles.

Sun Oil Co. used the coating to resist "Carbon C13." A steel company reports successful enameling of coke screens which gave better screening since the wet coke would not freeze and clog up on a porcelain enameled screen. Centrifugal and piston-type pump parts have been successfully enameled and their resistance to abrasion and corrosion has been extraordinary.

First, a brief explanation of the why's and what's of porcelain enamel. The first, or ground, coat is to promote adherence between the glassy enamel and the steel and to prevent blisters, black specks and other defects. Adherence is usually accomplished by cobalt oxide which provides the formation of the correct oxide coating on the steel to dissolve in, and unite with, the enamel glass. This oxide gives a dark blue color to the ground coat, which of course is of no help in forming the pure white finish of the subsequent coat(s). A key material of the enamel is "frit" which consists of small friable pieces of enamel glass, the result of quenching and shattering of the molten enamel as it is removed from the smelter. Porcelain enamel frit is composed of silica, borax, alumina and various other inorganic materials.

The Ideal—and How Closely Attained

The ideal enamel was once described by George Spencer-Strong of the Pemco Corp. as one having a reflectance (amount of opaqueness of a white coating as compared with magnesium oxide as a standard) of 85% or more, "AA" acid resistance, a Moh hardness of 7 (the diamond being 10), freedom from all defects, a thickness of 4 mils and which could be matured with the heat from a lighted candle. While this goal may still be a somewhat remote possibility, surprising progress has been made towards its accomplishment.

With antimony "super opaque" enamels reflectances of 70 to 74% are obtainable at total thicknesses of 0.012 to 0.014 in. (ground coat included). With zirconium opacified enamels, developed shortly before the war, reflectances of 70 to 74% are obtainable at thicknesses of 0.009 to 0.011 in. (total). Recently titanium opacified enamels have been developed, giving reflectances of 74 to 78% at thicknesses of 0.005 to 0.007 in. This titanium type is acid resisting, has excellent coverage and good scratch and abrasion resistance in one thin coat, whereas with the antimony and zirconium enamels a second coat of acid resisting enamel must be given if such a property is required.

Though the enamels can hardly "be matured with the heat from a lighted candle," firing temperatures have been reduced recently from 60 to 100 deg. Thus prior to the war enamel ground coats were matured at 1580 F but now 1520 F is all that is needed—not a great temperature reduction but important as to critical limits regarding warpage.

One of the oldest "new" developments is the use of one coat colors, that is, the applying of brown, black, green, blue or gray directly to the iron or steel with no preceding ground coat. There has been constant improvement in the enamels so that now greater varieties of colors are possible. Appearance is often equal to two-coat work and breakage has been reduced because of thinner applications.

During the war special enamels for special applications were developed, including acid-resisting ground coats for items where corrosion-resistance is prime, mat enamels where it is undesirable to have reflected light and heat resisting enamels that are effective up to 1100 F.

The reduction of firing temperatures has been important. In the past it was necessary to fire ground coats at higher temperatures than cover coats. Now ground coat is being fired with cover and at the same time and temperature. One can go farther—fire all sheet iron enamels, including ground coat, colors, white, acid resisting, at the same temperature. Other advantages are less warpage, use of lighter gages and reduction of troublesome firing defects.

Porcelain enamel, being fundamentally a glass, will break when abused. Generally decreased thickness of application increases ability to withstand abuse. Hence, there is a constant search to increase opacity of white porcelain enamels and striving for satisfactory coverage with thinner applications. Note the thinner coatings with titanium enamels as noted above. The opaque-giving qualities of titanium has already been discovered in the paper and paint fields —to mention just two. Thus magazines sometimes use titanium-impregnated paper so that print and photos will not show through from the back of the page. Titanium has also made possible the one-coat painting enamels.

The terms antimonies, zirconium and titanium enamels all refer to the white enamels and to the material with which the frit is opacified. Processing of each is the same. When antimony became scarce prior to the war, zirconium opacified frits were developed and many preferred them because of their higher covering power. However, they are not as scratch- or abrasion-resistant as the antimony enamels and are more subject to corrosion or chemical attack. Recently, the titanium enamels have been developed which are more opaque than either of the other two and, in addition, are acid resistant and are highly scratch- and abrasion-resistant. These titanium enamels are still new and are more expensive, but it

is hoped that these advantages will offset the higher cost.

According to one authority the use of titanium oxide as an opacifier in the frit makes possible the reduction in weight of application of the white enamel to less than one-half that employed with zircon enamels.

For a long time porcelain enamelers have been seeking a method of eliminating the conventional dark colored ground coat and employing white enamels directly on the metal. Several means are being utilized by the steel manufacturers in developing enameling irons for the one-coat base. There are three methods for preparing these irons: Modifying the processing of the iron to reduce the amount of impurities, stabilizing the carbon in the iron by the addition of titanium to the molten metal prior to pouring, and plating cold rolled steel with metals that are especially suited for enameling and which aid in the adherence of the white enamel.

Nickel Flash Treatment

The first two types of enameling iron require a nickel flash treatment in the pickling. A microscopic metallic nickel coating is deposited on the steel by immersing the pickled steel for several minutes in a hot nickel sulfate solution, with careful control of concentration, pH, temperature and immersion time.

The white enamels, possibly zircon or antimony-molybdenum type, are applied 40 to 50 grams per sq. ft., an even coat being necessary to avoid burned through areas at 1500 F firing.

The third type of steel does not need the nickel flash because of the coating already on the sheet. Here the antimony-molybdenum white enamel is applied and fired at 1300 F or lower. One can also enamel regular cold-rolled steel or enameling stock with these low temperature enamels by using a heavy nickel flash treatment.

Advantages of low-fire enamels are: lower fuel cost, lower maintenance of furnace, less warping of steel, less distortion of ware, more complicated shapes possible of enameling and more variation in gages of metal on the same part that may be employed.

New developments in soft ground coats, which fire at 1500 F are available in a wide range of color for items such as parlor heaters requiring a good appearing, heat and corrosion-resistant finish. New acid resisting ground coat enamels have been found satisfactory. In some new applications enamel has been selected because of high abrasion resistance, while in the electrical field, because of high dielectric properties.

The Bureau of Standards developed an enamel for exhaust systems of aircraft and naval vessels, less than 3 mils thick, withstanding 1300 F for long intervals, which compares well with the super alloys, previously mentioned. But even stainless steel and other heat-resisting alloys have been coated with porcelain enamel.

Copper and noble metal can be enameled and some work has been done on enameling aluminum; however, the important base metal as yet is iron.

Each application for porcelain enamel presents its own individual problems as to cleaning, enamel application, number of coats, firing, temperatures, etc. However, fundamentally all wet processing of porcelain enamel is the same. A frit is made, ground under proper suspension, applied by spraying or dipping and fused to the metal. Dry process enamel (no liquid used in grinding) is applied by dusting. The different finishes obtainable with the various enamels are largely due to variation in enamel compositions.

Preparation Before Enameling

More emphasis is being placed on proper preparation of the metal for enameling. Often the ware is pre-cleaned shortly after fabrication. With "washers" the drawing compounds are removed, leaving the ware proper for normal cleaning. Where mass production is feasible continuous cleaning and pickling are employed. Better control is obtained with automatic temperature devices, softened water, filters for the nickel sulphate solution and more rigid chemical testing of solutions. Some plants are using spray cleaning and pickling, especially where the spray can reach all surfaces.

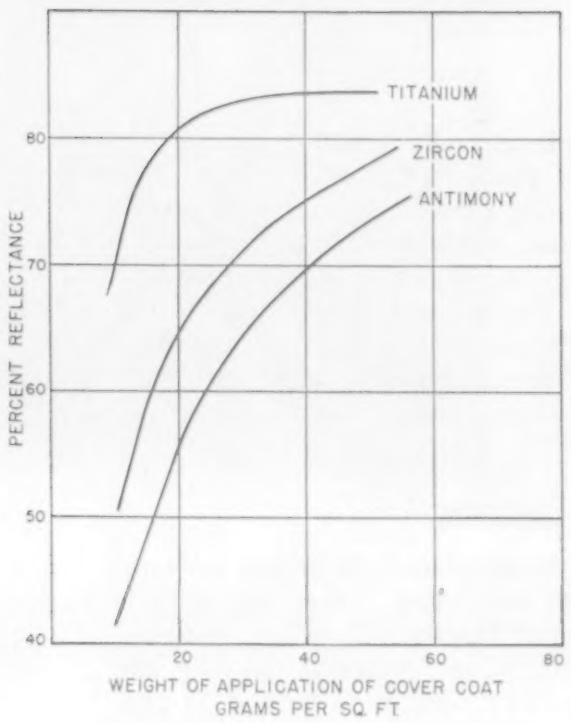
In one novel process the ware is heated to around 1500 F in a reducing atmosphere, resulting in a bright, clean metal surface suitable for porcelain enameling without further treatment. A proposed method is the Kolene process. The part is immersed in a molten salt bath, the cleaning being done by an electric current. Next the part is rinsed in a hot water bath, enclosed because of the violent reaction between the molten salts and water. The piece is now ready for enameling.

Automatic spray machines make possible maintenance of more uniform coatings, while keeping the spray rooms under pressure with filtered air reduces the number of imperfections from airborne contamination. Here it is possible to reclaim a high percentage of over-sprayed enamel and re-use it without impairing the quality of the final product. Electrostatic spraying is often feasible in big scale production, best results being on flat surfaces or exterior parts of symmetrical shape. Essential are close control of the consistency of the milled enamel and of the atomizing pressure.

Porcelain enamel should normally have a coefficient of thermal expansion somewhat below that of the steel or cast iron being enameled. The cover coat enamel of cooking ware should have a lower coefficient than for flat ware to resist thermal shock; enamel on the beads and handles of pots and pans should have a high coefficient.

Enamels are fired over a wide range of temperatures, depending on the type of metal, composition and fusibility of the enamel and end use of the product. Thus it ranges from 900 to 1000 F for coating aluminum to 1550 to 1800 F for heat-resisting enamels. The time interval ranges from 2 min. to 1 hr.

Various tests for heat-resistance are used. For the tops of cast iron space heaters that become red hot in service a thermocouple is imbedded in the top to be tested. The assembly is heated rapidly and the temperature noted at which the enamel fails, usually



Reflectance versus weight of application of antimony, zircon and titanium opacified enamels.

700 to 1250 F. A simple test for burner grates on gas stoves is to maintain the burner at maximum capacity for 8 hr. Though red hot, the satisfactory burner will retain an adequate enamel coating.

Titanium Enameling Steel

With improvements in the enamel have come corresponding improvements in the steel. Since titanium was found desirable in the enamel it was found equally so in the steel, the Inland Steel Co. having gone far with their "Ti-Namel," which often requires but one coat. The steel has a minimum titanium-to-carbon ratio of 4:1, the theoretical ratio in titanium carbide (TiC). This carbide is comparatively stable under enameling conditions. Titanium also combines with nitrogen, sulfur and hydrogen to form quite stable compounds.

This steel is non-strain aging even in the as-annealed condition, so that drawn and fabricated products do not exhibit strain lines or welts in areas critically strained. It was early found that with this steel the ground coat could be eliminated, the resistance to sagging was high and it was non-reboiling (thus eliminating enamel blisters).

The steel is a basic open-hearth product, analyzing: carbon, 0.09 max.; manganese 0.50 max.; phosphorus, 0.40 max.; sulfur, 0.50 max.; silicon, 0.10 max.; titanium, 0.20 to 0.50%. It is fully deoxidized with aluminum prior to the addition of titanium, as 40% ferro-titanium, to the ladle. Inland Steel engineers believe that all products rolled from carbon steel can also be rolled from the Ti-Namel.

Rockwell B hardness is 10 to 15 points higher than steel without titanium; 15 to 25 points over enameling iron. Tensile strength is 50,000 psi.; yield strength at 0.2% elongation is 22,000 psi. It is believed to be highly resistant to hydrogen penetration, which fact eliminates "fish scale" of the enamel.

One must avoid scratches in the metal shop as they will not cover with a single coat of white enamel. It is Inland's belief that the stock can be produced sufficiently soft to equal shearing quality of mild steel. It is stiffer than enameling stock, hence possible springback must be allowed for. In shallow drawing there is less "oil-can" effect or "loose" metal than with enameling iron, an observation that applies to stove end panels, table tops, etc. However, where one end is drawn deeper than the other, such as some stove door panels, there is a tendency for a springing out of the flanges near the open end. Inland claims that the deep drawing quality is "exceptionally good," though convincing experience is so far lacking. Wear with cast iron dies is naturally more severe than with enameling iron. One manufacturer extrudes the Ti-Namel, side walls being thinned from No. 16 to No. 19 gage.

The steel welds quite readily by any of the known methods, though there is dissatisfaction with one coat white enamel. Satisfaction prevails with welds by spot, seam, pressure and arc welding with special rod. In the gas welding field the enamel "takes" well with the oxy-hydrogen method, but thumbs down on oxy-acetylene! Heliarc, using argon, seems an encouraging method. When using oxy-acetylene, a pick up of carbon from the welding gas and loss of titanium by oxidation are harmful.

Only the zircon enamels have been used to date when the white is applied directly to the titanium enameling steel. These enamels have good reflectance at low coating weight, good resistance to "burning through" and will withstand several refirings.

In enamel firing, continuous furnaces produce a finish freer from enamel blisters in the first coat than do the box type. Blisters are caused when water in entrapped salts is being driven off during the firing cycle, probably in the early stages. With continuous furnaces this moisture is driven off in the pre-heat zone, hence eliminating blister tendencies. Regular acid-resisting enamels fire blister-free in both continuous and batch furnaces.

When planning for one coat ware redesigning of some parts is sometimes necessary since open corners and tight fitting parts which are forced into position in assembly will generally cause chippage.

Inland recounts four companies and ways in which the titanium steel is being enameled: (1) Dark colored porcelain enamels for chemical and electrical equipment, replacing stainless steel and mild steel for certain parts where complete enamel coverage is needed and difficult to obtain with mild steel; (2) ground coat plus one or two coats of white on stoves, refrigerators and miscellaneous parts, thus done because the enameler has no nickel flash tank nor is equipped to apply the white economically; (3) two coats of white—zircon and acid-resisting; and (4) one coat of zircon white for interior of refrigerators where the inspection standards are not as high as for exteriors.

This fourth company reports a saving of 15.44% in cost over enameling iron with ground coat and two coats of white, his previous set-up. In addition, a 50% increase in production is possible.

The No. 3 company (above), making burner bowls, found a 3% cost saving, which includes a reduction in enamel shop scrap loss of 1.6%, but does not include savings due to reduction in assembly or field losses. It does not include 30% increase in production. For company No. 2, however, there was an

increased direct cost of 10% which, however, was probably offset by indirect benefits.

Coating Aluminum

So much for enameling of titanium steel. With the increased use of aluminum it was natural to consider the possibilities of enameling that metal. Since the aluminum melting point is 1250 F enamels must be applied at lower temperatures than for steel.

Enamels for aluminum are made with very good acid resistance and are available in various colors. Aluminum is usually prepared by cleaning with a degreaser and given a dichromate dip. Alkali cleaning or sandblasting prove harmful. The ground coat is sprayed, dried, then fired or fused at 930 F. After cooling, the cover coat, a different composition, is applied and fired similarly in an electric or muffle furnace, the time ranging from 5 to 30 min., depending on thickness of parts and weight of load.

High Temperature Ceramic Coatings

One of the most interesting modern developments is the coating of plain carbon or alloy steel with special enamels to better resist prolonged high temperatures. Thus in aircraft, especially jet-propelled, flame tubes, turbine buckets, exhaust stacks, or collector rings, space heaters, smoke pipes, super heated steam pipes and annealing covers used in heat treating metal have been so dealt with experimentally through a joint effort of Power Plant Laboratory, Air Materiel Command, Wright Field, Dayton, Ohio and the Department of Ceramic Engineering, University of Illinois, Urbana, Ill.

Among the compositions introduced into the first of these special enamels are alumina, beryllia, ceria, diaspore, zircon and zirconia. Such a ceramic coating was applied, 2 mils thick, to the alloy buckets of supercharger turbine wheels, resulting in "considerable" lengthening of service life. After 227½ hr. operation a coating ½ mil thick still remained. A coated specimen of 316 stainless steel was heated for 450 hr. at 1500 F with apparently no change from the original coated condition. SAE 1020 steel was subjected to long periods of extended heating at up to 1600 F with no decrease in ductility. Flame tubes so coated had double their original life.

In February, 1947, the National Bureau of Standards officially reported new all-crystalline porcelains, with exceptional mechanical and dielectric strength up to 2000 F. The purpose of development was to find a material resisting deformation up to 2000 F in jet propulsion and gas turbine engines. A representative high-beryllia porcelain contains 84% beryllia, 8% zirconia, with small amounts of lime and alumina; a typical high-zirconia composition is 80% zirconia; 10% beryllia and 10% magnesia.

Tests show that all of the compositions are very resistant to deformation or creep up to 1800 F for long periods. A typical specimen showed elongation of 0.23% after 2600 hr. of applied stresses of 9000 to 14,000 psi. At 1900 F or higher the tendency to creep is more pronounced.

Physical Characteristics of Typical Porcelain Enamel

Hardness—(Moh)	3½-6
Abrasion Resistance (PEI)	30-60 plus % residual specular reflectance
Abrasion Resistance (Tabor)[1]	0.008 gr. for best types
Torsion Resistance (PEI)	0.016 in. - 20 deg. - 30 deg.
(PEI)	0.009 in. - 25 deg. - 40 deg.
Acid Resistance	Highly resistant enamels available
Alkali	Not resistant to hot alkali solutions
Solvents—Organic	Resistant to all
Temperature	700-1100 F[2]
Weathering	Acid resistant grades not affected
Ultra Violet Light	Not affected
Colors	Can be produced in all colors
Diffuse Reflectance (whiteness)	As desired up to plus 80%[3]
Total Reflectance	As desired up to plus 85%[4]

NOTES:
[1] 1600 cycles with 1000 gram load and CS17F wheel.
[2] Higher temperatures are resisted by special types.
[3] This is for normal application weights. Higher values have been obtained in special circumstances. Normal commercial diffuse reflectances on applications average about 74%.
[4] Since total reflectance is a function of diffuse reflectance consideration from note 3 applies here also.

As to hardness, including resistance to abrasion, the physicals depend on the composition and bubble structure of the coating. In general, the Moh hardness is from 3½ to 6. Some of the more recent developments are so hard that it is extremely difficult to scratch them with a sharp tool steel blade. Thus, all porcelain enamel coatings are considerably harder than organic finishes and plastics, and some of the better ones are superior to many metal finishes in resistance to scratching.

The standard of abrasion resistance for the test is plate glass so abraded that it has lost 50% of its specular reflectance or gloss. Porcelain enamels range normally from about 10% below this figure to more than 10% above same. The Tabor figure has been included because it is more familiar to many laboratories than the PEI test.

Under torsion resistance, according to the Porcelain Enamel Institute test, rough limits are given for two total enamel coating thicknesses, that is, 16 thousandths and 9 thousandths in.

In the choice of base coating materials properties of refractoriness, glass forming tendencies, adherence, elasticity and low solubility for metal or its oxides must be considered carefully. Fluxes are usually at a minimum and refractories at a maximum in high temperature coatings.

In the interest of thoroughness and fairness one must mention the chief drawbacks of porcelain enamel. Public enemy No. 1 of course is "chippage" (the industry prefers to call this "break," "fracture" or "damage"—"chippage" is due to abuse in service), but the newer thinner finishes are helping this problem. Moreover where porcelain enamel fails to cover the metal surfaces, if only in minute pores, there is no protection, which is contrary to metal plating. Thus an exposed pore in zinc plating is at least partially remedied by galvanic action and the formation

of a chemical compound of zinc and steel which has some corrosive resistance. The lead platers sometimes claim that pores in lead plating heal up and are finally as effective as the correct plating.

It is believed that the good features of the material have been overlooked for many years by industry in general.

More Applications

As to additional new applications of porcelain enamel, some experimental work has been done in enameling stoker screws and parts with an acid resisting type. Abrasion and acid resistance of the enamel coating should reduce the corrosion of the screw due to the sulfur in the coal and thereby greatly increase the life of the part. Porcelain enamel coal chutes have been found to decrease the angle at which the coal will slide, thereby making it more efficient. It also increases chute life, again because of abrasion and corrosion resistance.

Enamel is also being used for lining batch mixers used in food and other industries. The finish is giving excellent results and is desirable over other finishes because of its ease of cleaning.

There are a great number of other items which have been enameled with varying degrees of success, or on which enamel is the possible and logical application. Among these are thermos jug linings, flue pipe, chimney pipe, fire extinguishers, reflectors, permanent signs and markers, signal blades, gasoline pump dials and housings, scale parts, hoppers, chutes, food handling equipment and fixtures, steel tile, wall registers, heater dials, photographers' equipment, poultry pans, and feeding equipment, name plate guides on textile machinery, wainscoting, flashings, shingles, shutters, awnings, wall panels, baseboards, electric irons, undertakers' preparation tables, humidifier pans, utensils, water meter jackets, and bubble caps in oil refineries.

The use of enamel in coke screens, mentioned early in the article, merits further explanation. A chemical company wanted buckwheat coke that passes through a 5/8-in. opening, but not through a 3/16 in. mesh. On ordinary screening coke dust caked so hard it could not be brushed off. Galvanizing and various paints failed. Then vitreous enamel was applied at 1500 F followed by "Heresite," an organic finish made by Heresite & Chemical Co., Manitowoc, Wis. at only 450 F. It lasted 55 days on an average without cleaning, present costs being only 4% of original costs. It is believed the same screen can be applied to flue dust, ore, stone, coal, sand and gravel.

The A. O. Smith Corp. has built a large new factory at Kankakee, Ill. for the manufacture of porcelain enameled hot water storage tanks for the home. The same company is also promoting a porcelain enamel or glass-lined silo, already on trial at neighboring farms. They are about 14 ft. in dia. and 60 ft. high, closed at both bottom and top and with a discharge mechanism at the bottom to remove the silage. The chopped silage is charged into the top, the whole silo being kept tight so there is no spoilage. Their use may be extended to the bulk storage of food products as the container offers sanitation, good preservation and freedom from contamination.

Motor car and accessory manufacturers are interested in coating mufflers and tail pipes with enamel, but lack of facilities in their own plant and filled-to-capacity condition of jobbing plants prevents commercial exploitation. This same lack of facilities hinders development of other interesting potential applications, such as electric transformer tanks.

To get back to porcelain enamel houses, panels in the Higgins house are 4 ft. by 8 ft., mounted back to back, with an insulating cement between the panels. The water lines, gas and electric wires run through this cement to outlets through special openings which are prefabricated in the panels. Enamel shingles and floor tile are used, while the windows are of metal frame. In the Lustron house the panels are only 2 ft. wide and are embossed and mounted together on a steel frame, using a synthetic rubber type of material to seal the space between the edges of the panels. Insulation is applied to the back of panels before mounting.

In concluding present actual uses one might mention electric light reflectors, advertising signs, steel wall tile, street signs and parts for electric roasters. White enameled hamburger parlors and filling stations are often seen by the automobile tourist.

A committee has been formed by the Porcelain Enamel Institute, Washington, D. C. for the preparation of workable standard tests and specifications. New equipment for testing include the Photovolt Reflectometer, the gouge and scratch test machine and abrasion tester and the thermal shock and acid solubility test equipment of the Enameled Utensil Manufacturers Council. The new Photovolt Reflectometer has a scanning head with light source, filter and photosensitive cell. It indicates reflectance directly on a scale of a millivoltmeter calibrated in per cent reflectance, set to read correctly on a panel of known reflectance. Most of the other instruments named above are for research, but the thermal shock and impact test machines can be adapted to production use.

Tests have also been developed for warpage of flat ware, sagging of iron and steel sheets for enameling, torsion, impact and acid resistance. Bulletins are also available from the Porcelain Enamel Institute on "Design and Fabrication of Metal Parts for Porcelain Enameling" and "Production of Castings for Porcelain Enameling."

Acknowledgement

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MATERIALS & METHODS MANUAL

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This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Low-Alloy, High-Strength Steels

by the Editors, MATERIALS & METHODS

The eight or ten steels which fall into a group known tentatively as low-alloy, high-strength steels are finding rather wide application in those fields where a reduction in weight may mean a considerable saving both in original cost and in operating costs. While the actual forming and working of these steels is relatively simple, the inherent advantages in them is not obtained unless the products are properly designed. In addition to describing these steels, their characteristics, and their working and their corrosion resistance, this manual rather thoroughly discusses the design factors entering into their use.

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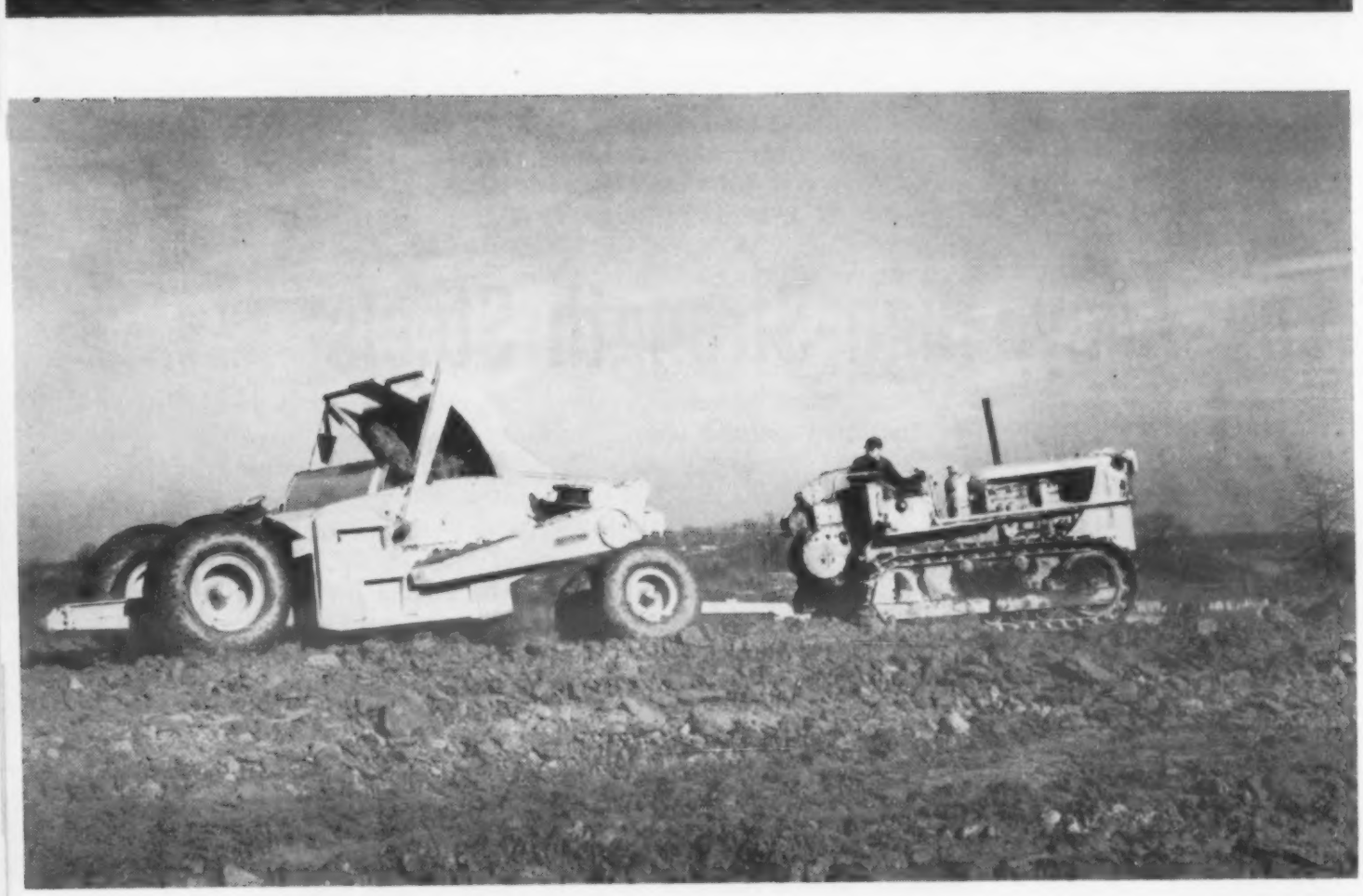
Materials & Methods, July 1947

(Published since 1929 as Metals and Alloys)

High resistance to corrosion, when alternately wet and dry, led to use of high-strength steels in tainter gates and roller gates of many dams. Shown is Mississippi River Dam No. 6 at Alton, Ill.



Adaptability for forming and welding are essential in high-strength steel used in earth-moving equipment.

Increase of 2500 lb. in payload capacity was effected by using welded high-strength steel in these trailers.

Introduction

Following a number of sporadic attempts, both in America and abroad, the weight saving era in worldwide construction finally got well under way in the early 30's. Experimental applications of various metals had been made since the turn of the century to meet a growing consciousness that needless weight in structures was a costly drag on their useful functions and a serious drain on basic raw materials.

Steels higher in strength than ordinary structural grades had been used over a period of years in the parts of some bridges, ships, and in subway cars for the City of New York. Likewise, in the absence of wholly suitable low alloy steel compositions, attempts were made to reduce the weight of various structures, notably railway passenger car equipment, by employing both aluminum and stainless steel.

Various objectives were sought in these early instances of weight reduction. Engineers in Great Britain had economy in ocean freights and handling charges in mind, principally, and made some progress toward these ends through weight reduction by the use of carbon steels containing generous additions of silicon and manganese. The European engineers made use of similar steels, and early in 1933 the Germans completed the construction of the "Flying Dutchman," the first light-weight "streamlined" train ever built using a high strength steel. This composition contained additions of silicon, manganese, and copper and was known as St.52.

In America, early in the century, some use had been made of a 3¼% nickel steel in certain parts of bridges, and somewhat later a steel containing about 1.6% manganese was employed as an alternate. The conservation of space and weight were early considerations in this country.

The high-strength construction steels, applied with some effect in the early years of the development, were those using carbon with nickel, manganese, or silicon as their principal strengthening elements.

But it was not until early 1933 that forerunners of the group of steels now known as high strength-low alloy steels had been developed and introduced initially in the transportation field. It was then that a survey of the railroad industry disclosed a desire on the part of its leading engineers to eliminate the excess dead weight existing in rolling stock. These engineers were asked what was required in the way of improved properties in steel to provide lighter and more efficient structures, while at the same time sacrificing nothing in the service life or maintenance of the equipment.

Their wants were almost identical. They needed greater strength to permit a substantial increase in unit stresses, and thereby make possible a proportionate decrease in section modulus. This meant the employment of lighter gages and, consequently, their next demand was for a greater degree of resistance to corrosion in order that the rate of attack would be retarded sufficiently to warrant the reductions made in the sections employed. Next they required a composition that could be formed easily, hot or cold; readily welded without heat treatment, and generally without the need of subsequent annealing, or stress relieving.

It was requested also that these properties be provided in the as-rolled condition of the steel, because obviously large structures such as railroad freight and passenger cars could not be subjected to heat treatment after fabrication. Lastly, it was asked that all of these improved properties be integrated in a steel of relatively low cost. These specifications constituted quite a large order, but the important advantages so clearly indicated proved a sufficient spur to ingenuity, thus causing the metallurgists to create this new type of steel. Since the introduction of these steels in 1933, progress has been rapid, and it is now evident that as the great economies to be realized are better known, more and more will the structures now employing ordinary steel be displaced by high strength construction.

In this development considerable misunderstanding has been caused by the use of terminology such as high tensile steel, low alloy steel, mild alloy steel, and light weight steel. Some of these designations are inaccurate and misleading. At present the group of compositions is nameless, insofar as official classification is concerned, but the term *high strength-low alloy steel* has gained general favor and is now used by most producers. Moreover, there is no official definition of the properties and characteristics of steels qualifying in this group. One which has been proposed to the American Iron & Steel Institute follows:

"High Strength-Low Alloy Steels are a specific class of steels, in which enhanced mechanical properties, and, in most cases, good resistance to atmospheric corrosion, are obtained by the intentional incorporation of moderate proportions of one or more alloying elements, other than carbon.

"These steels are generally intended for applications where savings in weight can be effected by reason of their greater strength, and where better durability is obtained because of their other desirable characteristics.

"These steels are supplied to minimum mechanical properties and are normally furnished as rolled, as annealed, as normalized, or as stress relieved and are intended for use without further heat treatment except for preheating, postheating or stress relieving operations which are sometimes used in conjunction with metal-arc welding."

Throughout this manual high strength-low alloy steel will be referred to as *high-strength steel;* plain carbon steel containing 0.20% copper will be referred to as *copper steel;* and plain carbon structural steel will be referred to as *ordinary steel.*

Representative High Strength—Low Alloy Steels

Data given, except for noted exceptions, are for plate ½-in. thick in the hot-rolled condition

Brand Name	Composition, % C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Zr	Al	Yield Pt. Min., Psi.	Ten. Str., Min., Psi.	Min. Elong.	Producer
Aldecor	0.12 max.	0.15-0.40	0.08-0.15	0.05 max.	0.35-0.75	0.35-0.60	—	—	0.16-0.28	—	—	50,000	70,000	[a]22%	Republic Steel Corp.
Cor-Ten	0.12 max. •	0.20-0.50	0.07-0.15	0.05 max.	0.25-0.75	0.25-0.55	0.65 max.	0.50-1.25	—	—	—	50,000	70,000	[b - c]	Carnegie-Illinois Steel Corp. Tennessee Coal, Iron and Railroad Co. Geneva Steel Co. American Steel and Wire Co. Republic Steel Corp.
Double Strength	0.12 max.	0.50-1.00	0.04 max.	0.05 max.	—	0.50-1.00	0.50-1.10	—	0.10 min.	—	—	50,000	70,000	[a]22%	Republic Steel Corp.
Dynalloy	0.20 max. 0.12 avg.	1.25 max. 0.75 avg.	0.100 max. 0.080 avg.	0.05 max. 0.035 avg.	0.30 max. 0.05 avg.	0.60 max. 0.40 avg.	1.00 max. 0.60 avg.	— —	0.10 max. 0.08 avg.	— —	— —	50,000 —	65,000/80,000 —	[b - d] —	Alan Wood Steel Co.
Hi-Steel	0.12 max.	0.50-0.90	0.05-0.12	0.05 max.	0.15 max.	0.95-1.30	0.45-0.75	—	0.08-0.18	—	0.12-0.27	50,000	70,000	[b - c]	Inland Steel Co.
Manganese-Nickel-Copper	0.25 max.	1.40 max.	0.045 max.	0.05 max.	0.25 max.	0.30-0.60	0.50-1.00	—	—	—	—	50,000	70,000	[b - c]	Carnegie-Illinois Steel Corp.
Mayari-R	0.12 max.	0.50-1.00	0.08-0.12	0.05 max.	0.10-0.50	0.50-0.70	0.25-0.75	0.40-1.00	—	—	—	50,000	70,000	[b - e]	Bethlehem Steel Co.
N-A-X High Tensile	0.08-0.15	0.50-0.75	0.04 max.	0.05 max.	0.60-0.90	Resid.	Resid.	0.50-0.65	—	0.05-0.15	—	50,000	70,000	[e]	Great Lakes Steel Corp.
Otiscoloy	0.15 max.	0.90-1.40	0.08-0.13	0.04 max.	0.10 max.	0.30 min.	Resid.	Resid.	—	—	—	50,000	70,000	[a-d]25	Jones and Laughlin Steel Corp.
Yoloy	0.15 max.	0.60 max.	0.05-0.10	0.05 max.	—	0.75-1.25	1.50-2.00	—	—	—	—	50,000	70,000	[a]22	Youngstown Sheet and Tube Co.

Note—All of these steels, in thicknesses up to and including ½ in., are capable of at least meeting ASTM Standard Specimen cold bend of 180 deg. over a diameter equal to the thickness of the material.

[a] % elongation in 2 in., ASTM Standard Flat Specimen.

[b] $\frac{1,500,000}{T.S.}$ min. % elongation in 8 in., ASTM Standard Flat Specimen.

[c] For thicknesses under $\frac{5}{16}$ in., 22% min. elongation in 2 in., ASTM Standard Sheet Specimen.

[d] For thicknesses under $\frac{5}{16}$ in., 25% min. elongation in 2 in., ASTM Standard Sheet Specimen.

[e] Typical value for ½ in. plate, 27% in 8 in., ASTM Standard Flat Specimen.

General Characteristics

The high-strength steels, as has been indicated, were developed primarily to provide structural steels that would permit substantial weight saving in various types of construction. This could not be accomplished, however, without assurance that there would be no impairment of service life or safety and, consequently, provision against premature failure due to corrosion was of prime importance. Fortunately, some of the elements which impart strength to steel are also those employed to obtain good corrosion resistance. Conspicuous among these elements are copper, phosphorus, silicon, chromium, nickel, and molybdenum. Two or more of these elements in small percentages, combined with low carbon and varying degrees of manganese, constitute the chemical compositions of the principal steels now included in this group.

A minimum degree of several important properties must be possessed by a composition suited to the purposes for which this group of steels was designed. Otherwise, the steel would be inadequate to fulfill requirements in some one or more respects and would, therefore, be disqualified. Good resistance to atmospheric corrosion is needed in most cases; however, the degree necessary is obviously determined by the nature of the structure to be built and the environment in which it is intended to function. Thus, in railway freight car equipment and in mine cars, corrosion resistance is most important, but it may not be in certain parts of motor trucks and passenger motor vehicles, machine tools, and some structures employing heavy sections. It is indicated later in this manual how a determination can be made of the degree of corrosion resistance ordinarily needed to offset the reduction in thickness of high-strength steel members displacing heavier construction of ordinary steel.

Service experience and an exhaustive testing of samples in various atmospheres have demonstrated clearly that the superior atmospheric corrosion resistance of certain high-strength steels is due to the more dense, tightly adherent, and highly protective rust coat, or oxide film, which forms on their surfaces. One particularly important characteristic of this rust coat is its uniformity. It is practically free from spalling and the formation of tubercules which aggravate pitting and cause corrosion to progress steadily. Paint and other protective coatings, such as zinc and certain enamels, adhere better to high-strength steels, possessing good atmospheric corrosion resistance, than to ordinary steel. It is also reported that in certain special applications the use of these steels simplifies preparing parts to be polished, painted, or plated.

Other characteristics of the high-strength steels including their workability are described in appropriate sections of this manual.

High-strength steel products are generally available in the forms commonly supplied in ordinary steel.

Corrosion Resistance

In the manufacture of steel, one of the major operations involves the separation of the ore into its principal components, iron and oxygen. An article manufactured of steel always tends to revert to its original state, commonly known as iron oxide or rust. This change in form, or wasting away, is characteristic of all structural metals and is commonly referred to as rusting or corroding. Oxygen is the most important factor in this natural phenomenon, particularly in the presence of water, either as vapor in the atmosphere or as a liquid.

This tendency to corrode can be minimized only by interposing between the metal and the environment some barrier or defense against continued attack. Such a barrier may be a very thin invisible and continuous oxide film as is formed on stainless steel. On the high-strength steels it may be a visible, somewhat thicker coating of rust which is much more adherent and impervious and, under most conditions, a more effective barrier than the rust which forms on ordinary steel. Such an oxide will form on the high-strength steels which possess outstanding atmospheric corrosion resistance. A typical characteristic of the rust formed on ordinary steel is that it is loose and porous and will, under some circumstances, accelerate attack or induce localized corrosion. Thus pits are developed which may ultimately perforate the metal. A barrier can also be provided by applying a layer of another metal, or a coating of paint, or some other protective substance.

The rate at which the corrosion of steel proceeds depends upon at least two principal factors: (1) the environment to which the material is subjected, and (2) its chemical composition. For example, ordinary steel corrodes at an extremely slow rate in dry inland atmospheres, while in a contaminated industrial atmosphere its tendency to corrode is greatly increased. On the other hand, the highly alloyed stainless steels suffer no measurable corrosion loss in most media, although in some acid bearing water there may be a perceptible loss. The high-strength steels occupy an intermediate position, losing much less weight in most environments than ordinary steel and, of course, considerably more than stainless. The most striking difference in the corrosion rates of ordinary steel and of high-strength steel is found when they are exposed to severely contaminated industrial atmospheres. Since all ordinary steels are subject to loss of weight (i.e., thinning) by corrosion, preventive measures must be taken; otherwise, their safe and economic use is limited.

Commonly effective measures for minimizing corrosion will not suffice unless care has been exercised to keep the surface conditions of the metal free from entrapped dirt and moisture in laps and on ledges, because such conditions cause greatly accelerated attack at those locations. A more detailed consideration of this matter is given elsewhere in this manual.

Data have been published from time to time covering a large amount of corrosion testing of steels. (See bibliography.) These steels may be grouped under the general classifications of ordinary steel, copper steel, and high-strength steel and, therefore, only a brief summary need be given here regarding some of the general trends disclosed.

Atmospheric Corrosion

The copper content of an ordinary steel determines its degree of resistance to atmospheric corrosion, and as the amount of this element increases to about 0.25%, a progressive improvement is shown. Ordinary steels now

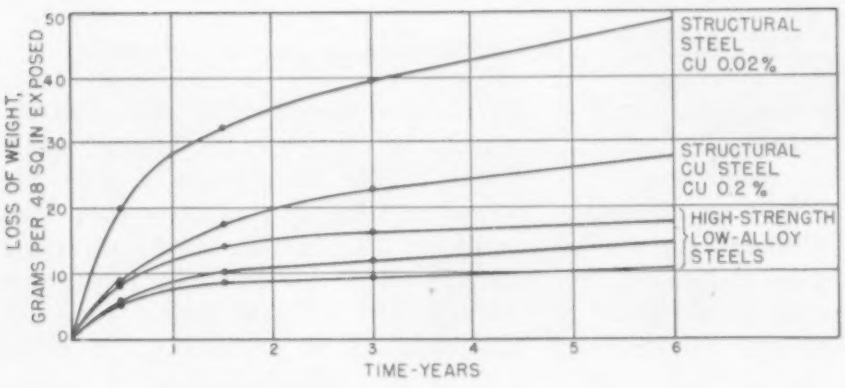


Fig. 1—Time-corrosion curves for steel typical of their classes after exposure to industrial atmosphere.

contain small and varying quantities of residual copper, and as this element increases with time, large differences are reflected in their resistance to atmospheric corrosion. Thus, no single index of performance for ordinary steels is possible. On the other hand, the copper steels commonly containing 0.20% minimum copper, give consistent and reproducible results when exposed to the atmosphere, and, consequently, can be used as an index. The atmospheric corrosion resistance of high-strength steels varies with the combination and content of those alloying elements most effective in building up this resistance. Several steels of this type possess two to three times the atmospheric corrosion resistance of copper steels, as has been demonstrated over a period of some years. Using the known criterion that copper steels (0.20% copper minimum) have approximately double the resistance to corrosion in the atmosphere of an ordinary steel containing 0.02% copper, the more resistant high-strength steels, offered to the trade, possess, in the main, four to six times the corrosion resistance of ordinary steel. Typical time corrosion loss curves for representative steels of the above mentioned classifications, after exposure in an industrial atmosphere, are shown in Fig. 1.

Sea Water Corrosion

The average penetration of ordinary steel, copper steel, wrought iron, and representative high-strength steels is about 0.004 in. per year for each surface exposed. However, in general the pitting on the high-strength steels is only about one-half the depth of that on the ordinary steels.

Corrosion in Inland Waters

Tests in uncontaminated running brook water having high oxygen content indicate similar corrosion resistance for ordinary steel, copper steel, and various high-strength steels.

Tests in various river waters show greater corrosion with increasing contamination for all steels. Although there is little difference between the performance of ordinary steel and the high-strength steels in river waters having little contamination, the comparative resistance to corrosion of some high-strength steels improves as the contamination increases.

Corrosion in Soil

Tests by the National Bureau of Standards in many soils show that the corrosion resistance of representative high-strength steels is not sufficiently better than that of ordinary steel to warrant claims of superiority in most instances. This type of corrosion is characterized by a great tendency toward localized pitting which results in large variations in loss of weight between individual samples of the same steel.

Corrosion in Service Applications

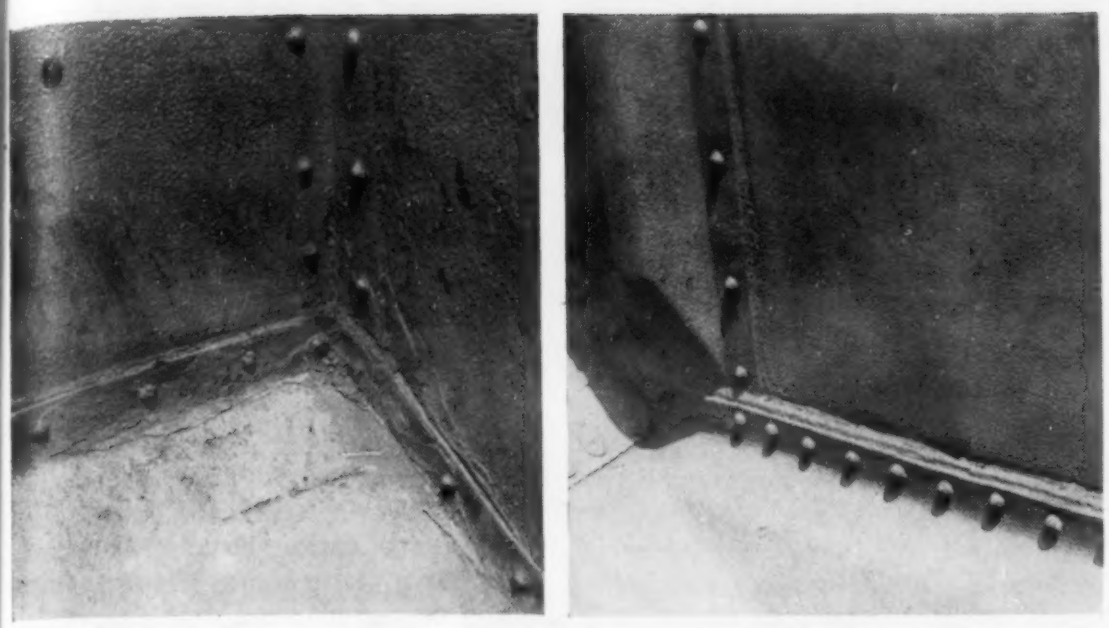
As has been previously mentioned, the corrosion resistance of a material cannot be expressed quantitatively (as yield point is described, for instance) because it is only a relative term. Furthermore, no material is resistant to all corrosive conditions to which it might conceivably be exposed. Its performance can only be compared with that of other materials under similar conditions.

This contention is in accord with the point of view that atmospheric rack tests do give strictly comparative results under a specific environment. Such tests differentiate between the performance of various steels and permit a close evaluation of the trends in weight loss due to corrosion.

The superior atmospheric corrosion resistance which most of the high-strength steels have shown in rack tests has been confirmed by their performance in many different kinds of service. This superiority is particularly evident in all applications in which the materials are subjected principally to atmospheric corrosion. As an illustration, after about 10 years' service there was practically no loss in thickness in the uppermost area of open top railroad car side sheets made of a high-strength steel having good atmospheric corrosion resistance. Copper steel in a similar location and service lost approximately 0.02 in., and ordinary steel three times this amount. In another instance where both compositions were exposed for 11 years in a highly contaminated industrial atmosphere, an ordinary steel lost ten times the weight lost by one of the high-strength steels having good atmospheric corrosion resistance.

In those applications in which the materials are subjected to atmospheric corrosion, but also to abrasion and attack from leachings, the superiority of high-strength steel over ordinary and copper steels remains substantial. For instance, after 10 years' service, the loss in thickness at the lower edge of the side sheets of open top railroad coal cars constructed of high-strength steel was approximately 0.02 in., while copper steel in a similar location and service lost two and one-half times this amount. Even where abrasion and attack from leachings are most severe in such service, the superiority of some high-strength steels over ordinary and copper steels is still marked. This is shown by losses in thickness of approximately 0.07 in. for a high-strength steel of good atmospheric corrosion resistance, approximately 0.10 in. for copper steel, and about 0.16 in. for ordinary steel in the lower portions of the floors and in the hopper chutes. This superiority in performance has also been verified by the improved service life of mine cars constructed of high-strength steels.

In a ten year service test on a steamer which operated in a highly contaminated river, a high-strength steel lost approximately 0.02 in.; copper steel approximately 0.03 in., and ordinary steel 0.04 in. in thickness slightly above the water line. At a location somewhat below the water line, the high-strength steel lost approximately 0.04 in. only; the copper steel approximately 0.09 in., but the ordinary steel lost its full original thickness of 0.11 in.



(Left)—Formation of rust in layers, and spalling are typical of corrosion of plain carbon or copper steel in hopper cars. (Right)—Corrosion resistant high-strength, low-alloy steels form dense, adherent, relatively impervious rust, as inside this hopper car which has been in service 10 years.

Smooth, welded construction and use of high-strength steel lessen corrosion and substantially lengthen service life of open freight cars.

Protection by Coatings

In many applications, coatings of paint are applied to provide protection against corrosion. The most important item in obtaining good paint protection for a metal is the proper preparation of the surface before the paint is applied. The protective value of properly applied paint, due to better adherence to high-strength steels, endures longest on these steels; not so long on copper steels, and for a much shorter time on ordinary steels of low copper content. This better adherence of paint to the surfaces of high-strength steel is attributed to the less voluminous rust formed on the steel where moisture penetrates through the paint. The lighter, more adherent rust which forms on high-strength steel has less tendency to lift the paint. The tendency for the rust on these steels to spread laterally is also much less marked.

Galvanized high-strength steels are sometimes required in special applications where corrosion is severe; for instance, where chlorides are present. It has been found that these steels, when galvanized, are much more resistant to salt conditions than galvanized copper steel, which, in turn, is superior to galvanized ordinary steel. High-strength steels are available in both sheet and strip forms for such applications. The adherence of zinc coating to these steels in all usual fabricating operations is comparable with that on ordinary and copper steels. Where hot-dip galvanizing is necessary, special practices, particularly in pickling, are required because the most important feature in obtaining satisfactory adherence is primarily the development of a thoroughly clean surface on the base metal.

Fig. 2—Recommended side sill construction of high-strength steel hopper cars to prevent formation of corrosion pockets.

Notch Toughness

Toughness, as measured in a notched bar test, is of interest because it reflects the behavior at notches in actual structures. Such notches might result from improper design or fabrication, or may be present unavoidably. It must not be concluded that the notched bar values will be reflected primarily in the behavior of large structures, but the trends will be recognized unmistakably. For example, one of the criteria of notched bar toughness employed today is the refrigerated temperatures at which the notched bars are brittle. An actual structure may not exhibit brittleness at precisely the same temperature, even in the presence of a notch, but the steel which preserves its toughness to a lower temperature in a notch bar test will likewise preserve its toughness to some lower temperature in an actual structure.

High-strength steels are better than ordinary steels in notch toughness, whether the notch toughness be considered in terms of the number of foot-pounds at room temperature or in terms of the degrees Fahrenheit refrigerated temperature down to which they preserve their toughness.

These advantages in notch toughness are reflected in a superior performance of actual structures. A structure built of high-strength steel, as compared with a similar and correspondingly heavier structure of ordinary steel, will exhibit superior resistance to fracture under overload at notches, re-entrant angles, or under other conditions of restraint.

In commenting on notch toughness and/or sensitivity producers had this to say:

Question: Some authorities claim that welded structures of a monolithic

character, such as certain types of bridges and ships, require steels having a substantially less notch sensitivity than exhibited by ordinary structural grades. Do you recommend any of your high-strength steels for such applications?

Answer: (1) "The . . . high-strength steels are much more notch resistant than ordinary structural steel. The use of such high-strength steels will therefore be advantageous in structures where a higher degree of notch resistance is desired."

(2) "Our high-strength steels may be reported as demonstrating, by lab test and service, a uniformly higher toughness over ordinary structural steel. However, intelligent design that is wary of and seeks to eliminate reentrant angles, etc., a know-how of welding construction, are all more important than lab tests of polished specimens. No good quality in a steel can be sufficient to overcome, in the long run, a bad design. Variations in notch sensitivity in the as-rolled condition from heat to heat and gage to gage will be about the same as in structural grades, although the high-strength steels will average higher values than structural grades at low temperature."

(3) "Notch sensitivity is not a requirement of specifications covering materials for welded bridges and ships and we would, therefore, not hesitate to furnish either carbon steel or our high-strength steels for those purposes as long as they meet the specification requirements in other respects."

Fatigue Resistance

The endurance limit of a material, as determined by testing polished specimens, is considered to have little bearing on the fatigue resistance of full-size structures. Design and fabricating practices are far more important in this respect, since failures of structural members, subject to alternating or pulsating stresses, generally originate at some surface notch or discontinuity.

Laboratory tests of polished fatigue specimens indicate a trend in superiority of high-strength steels over ordinary steels as evidenced by higher endurance limits for the former. The ratios of endurance limit to tensile strength are 0.6 to 0.7 for high-strength steels, whereas with ordinary steel they are usually about 0.5.

Producers of high-strength steels, likewise, were asked to comment specifically on fatigue resistance and replied as follows:

Question: Endurance limit, as determined on polished laboratory specimens, has what bearing on structural designs involving fatigue?

Answer: (1) "Regarding fatigue, such evidence as we have denies any correlation between the endurance limit as determined from polished specimens, and the fatigue strength of riveted or welded joints. . . . Further research is proposed; but the evidence indicates that the stress raising characteristics of joint geometry will completely overshadow differences in composition of steel."

(2) "Absolutely none except a very rough empirical relation. We do not make or believe in endurance limit tests. Design and construction are far more important."

(3) "In testing steels to be used in structural designs involving fatigue or corrosion fatigue conditions, several specimens of various analysis . . . should be prepared and tested in the corrosive media or atmosphere expected to be encountered in actual service. In general, the steels that would stand up better than other steels in these types of laboratory tests, will show better results in actual service. However, the best test is one of service itself."

(4) "Probably none as applied to design. Laboratory fatigue tests are fatigue tests of the metal, per se, and not generally of design."

(5) "We believe that the test results of polished laboratory test specimens have very little bearing on structural designs involving fatigue, but that design has a material effect on the fatigue life of a structure. Polished specimens may, however, serve for comparative purposes of various structural materials and do indicate trends toward superiority of one material over another, all other factors being equal."

Abrasion Resistance

It is difficult to make a general statement with respect to the resistance to abrasion of any material, for the reason that there are many kinds of abrasion associated with different abrasive substances, and because abrasion is frequently combined in service with corrosion. There is general agreement, however, that the resistance of various steels to abrasive action increases with strength and, to some extent, with carbon content. Service tests have demonstrated that the abrasion resistance of the high-strength steels, with their inherently higher strength, is considerably greater than that of ordinary steel. This superiority is especially pronounced where abrasive action is encountered along with corrosion, as in most mobile structures which are used for the transportation of bulk ladings, such as open-top railroad freight cars; barges; mine cars; dump-truck bodies, and similar applications.

Joining and Working High-Strength Steels

The high-strength steels considered in this manual are as readily weldable as ordinary steels, indeed, welding characteristics have been a foremost consideration in their development. In heavier structures, overall welding costs for these compositions will be somewhat less than for ordinary steel due to the smaller volume of welding material required in joining the reduced sections. However, the maximum benefits to be derived from the use of high-strength steels will be obtained only in properly designed welded construction. The cost of welded structures should be less than that of riveted structures; fewer operations are required, and the volume of material used is reduced by the simplified welded construction. These lower costs will be most fully realized when engineering, management, and production personnel understand welding and base their designs, production planning, and shop operations upon it. In addition to the importance of designing expressly for welding, accurate layout; good fitting; pre-assembly; positioning, and, in general, the use of welding jigs and fixtures are essential to economic welded construction.

Welding Processes

High-strength steels, because they are low in carbon content, do not require special handling in most welding processes. They can be readily welded to each other and to ordinary steel. Preheating is not required to any greater extent when welding high-strength steels than with ordinary steel.

Here a high-strength steel girder is being fabricated through submerged arc welding. Web plate is 9/16-in. thick, 80-in. wide and 30-ft. long.

Whenever stress relief annealing is necessary, substantially the same practice is used as with ordinary steel.

Metal Arc Welding

Arc welding encompasses both shielded metallic arc and submerged arc welding, either of which may include manual or automatic machine welding. In welding high-strength steels the same techniques and same type of electrodes are used as for welding ordinary steel. Special alloyed electrodes are not essential because of the corrosion resistance provided by the enrichment of the weld deposit, due to the intermingling of the alloying elements from the base metal. The cast character of the weld deposit also contributes to corrosion resistance. Service experience and extensive tests have demonstrated that the corrosion resistance of weld deposits is equal to that of the base metal.

The use of ordinary unalloyed electrodes with the high-strength steels also provides welds of adequate strength, together with maximum ductility and freedom from cracking. Covered electrodes of the E-60 group or equivalent are recommended for metal arc welding and have been employed, generally.

Submerged Arc Welding

The same adequate properties as those described above result when the submerged arc process is employed. The welding wire normally used for ordinary steel is also recommended for submerged arc welding of high-strength steels. High welding speeds obtainable by this process on sheets and light plates, result in substantial economies. This process is an excellent method of joining high-strength steels in a wide variety of structures. Moreover, since laps can be eliminated almost entirely and welds are continuous, the structure can be sealed against moisture, and corrosion thereby minimized. High-strength steels are more readily welded by this process than ordinary steel and, thus, maximum benefits are derived when they are employed.

Spot Welding

High-strength steels in thicknesses of about ⅛ in. and less are spot welded with about the same welding conditions of time, pressure, and current as are used in the spot welding of ordinary steel. Surface conditions are important, and the material to be welded should be thoroughly cleaned either by pickling or sandblasting. Uniformly good results cannot be obtained with grease, paint, or rust on the surfaces of the material, but a light film of oil following pickling is not considered detrimental.

Spot welds in the high-strength steels have adequate ductility and their shear strength is proportionately greater than that of spot welds in ordinary steel. These steels are readily spot welded to each other and to ordinary steel provided such steels are sufficiently spot weldable in themselves. They are also readily spot welded to the austenitic stainless steels. The spot welding of high-strength steels to nonferrous metals should not be undertaken without careful preliminary investigation.

Under special conditions other welding processes can be employed, but are not commonly used.

Weight Saving Through Welding

It is pointed out elsewhere in this manual that the substitution of high-strength steels for ordinary steel may achieve weight reduction averaging about 25% in most structures. Where welding is used rather than riveting, a still further weight saving is effected and, in some instances, the combined savings are most substantial, even approximating a total of 40 to 50% in certain components of some structures.

Welded Construction and Corrosion

Riveted construction involves many corrosion traps such as laps and seams, the most harmful of which are horizontal ledges formed by lapped joints. At these locations moisture is trapped between the faying surfaces, and dirt and coal fines, which frequently contain sulfur and other corrosive compounds, accumulate upon the ledges. Such conditions result in localized corrosion which may cause premature failure. Due to these conditions, high-strength steels having good atmospheric corrosion resistance have sometimes failed locally, while the adjacent

Arc welding is being used to fabricate this Granby-type ore car made of high-strength steel. Smooth sides and absence of pockets reduces corrosion.

metal was virtually unaffected. Continuous welds which seal laps and seams and thus prevent the forced penetration of moisture, as by driving rainstorms or the velocity of wind created by fast moving vehicles, contribute substantially to the durability of the structures. Such continuous welds in properly designed construction, by whatever process made, form an important and effective safeguard against premature deterioration and add to the service life of the structures, thus avoiding costly maintenance and rebuilding operations.

Too much emphasis cannot be placed upon the importance of self-clearing and self-draining structures. This can best be accomplished in properly designed welded construction.

Riveting

When fabricating high-strength steels by riveting, ordinary steel rivets, appropriately spaced, have frequently been used. However, the use of high-strength steel rivets is desirable especially where shearing stresses are high or where corrosive or abrasive action is severe.

Rivets made of high-strength steels can be cold driven if their diameters do not exceed ⅜ in.; hot driving is recommended for larger sizes. These rivets should be heated to 2000 to 2150 F for driving with an air hammer, and to 1700 to 1900 F for machine driving.

Cold Forming

High-strength steels, despite their high yield points, can be satisfactorily worked in pressbrakes, drawbenches, presses, and other equipment used for cold forming, even when these forming operations are quite severe.

The principal differences in the cold forming characteristics of high-strength steels and ordinary steel can be seen in the accompanying diagram. High-strength steel, because of its greater strength, generally requires more force to produce a given amount of permanent set in sections of equal thickness. This difference is proportional to the heights of the two "flow curves" shown. However, because high-strength steel can usually be employed in thinner sections, the force required in most instances is little greater than for ordinary steel.

The height of the flow curves at a given strain also represents the strength of the formed part. A comparison of the two flow curves in the diagram shows that, for the same part formed from the two steels, the strength of the high-strength steel part is substantially greater than that of the part formed from ordinary steel. When working with high-strength steel, somewhat greater allowance for spring-back must be provided in the forming dies. The amount of spring-back is proportional to the height of the flow curve and the relative amounts for high-strength and ordinary steel, for a strain of 0.2, are shown in the diagram.

The changes in practice necessary for cold forming high-strength steel consist chiefly in making provision for more liberal radius of bends, slightly increasing die clearances, and allowing for more spring-back. These changes cause no serious difficulties after the shop personnel becomes familiar with the characteristics of these steels.

It is recommended that, for cold forming, the inside radius of the bend be at least equal to the thickness of the material up to 1/16 in. inclusive; at least twice the thickness of material for thicknesses over 1/16 in. to ¼ in. inclusive, and three times the thickness of material for thicknesses over ¼ in. to ½ in. inclusive. High-strength steels of drawing quality can be worked with somewhat smaller radii than those recommended above.

The usual precautions and practices common to the successful forming of ordinary steel are equally important in forming the high-strength steels. Greater deformation can be accomplished if the bending or drawing operations are performed at moderate speeds. It is preferable to avoid these operations in temperatures below 60 F.

It is not possible in some instances to obtain hot rolled high-strength steel shapes in sections as light as desired. In such cases a much closer approach to the maximum possible weight saving can be accomplished by cold forming a corresponding shape from flat rolled steel. A fairly complete range of light, cold formed sections, such as angles, Z-bars, and channels is now available. Recent improvement in forming equipment, such as in stretch bending or tangent bending machines, makes the bending of these sections, as well as of eccentric sections, possible.

Gas Cutting

The high-strength steels can be gas cut wherever it is economical to do so. Cuts are smooth and approximately the same speeds and torch adjustments are used as for cutting ordinary steel. Gas cutting produces no harmful hardening in the heat affected zone.

Coping

Fabricating experience has indicated that certain precautions should be taken in coping steel. The following suggestions are considered good shop practice for both high-strength and ordinary steels:

When coping the high-strength steels, the tools should have a rounded corner, since sharp-cornered tools tend to form notches which cause cracks. Burrs and fins should be removed if coped edges are to be bent cold.

Hot Forming

High-strength steels are readily hot formed, and this practice is universally recommended for all thicknesses in excess of ½ in. Temperatures of 1450 to 1600 F at the dies usually give most satisfactory results. Due to their low alloy content, these steels do not harden appreciably upon cooling from hot forming temperatures, either in air or by the quenching action of the cold die surfaces. The mechanical properties of these steels are only slightly affected by hot forming; hence, no subsequent heat treatment is necessary to restore their original properties. It is recommended that the producers of the grades employed be consulted as to the proper temperatures to be used in operations involving forging, normalizing or annealing, and stress relieving.

Miscellaneous Operations

Shearing, punching, reaming, sawing, milling, and drilling operations can be performed on high-strength steel with little or no deviation from the practices employed with ordinary steels. The reduction in thickness which usually accompanies the substitution of high-strength steel should compensate for the slight increase in force required to perform most of these operations. In shearing and punching, tighter and more secure clamping should be used because the high-strength steels tend to pull more than ordinary steel. It has also been found that slight reductions in cutting speeds result in increased tool life.

Design Considerations

The design of all structures is based upon the same engineering principles of stress analysis and strength of materials. Every material of construction has its own unique characteristics and once a knowledge of these has been acquired, the problems of design take on the familiar pattern of analysis and of endeavor to utilize the material effectively and economically. High-strength steels are no exception though, fortunately, their proper utilization is largely but an extension of the vast experience accumulated over many years with ordinary steel. The long and well-established record of ordinary steel is an invaluable background of knowledge upon which to base the advances being made today in many different applications employing these superior compositions.

Structural members are proportioned on the basis of working unit stresses, derived by dividing a strength property of the steel by a suitable factor of safety. Most designs are based on the yield point, since it is the unit stress at which permanent set begins. Here lies one of the intrinsic values of the high-strength steels for they have a minimum yield point averaging 50,000 psi. as compared to 30,000 to 33,000 psi. for ordinary steels. The ratio of these values being very nearly 1.5 to 1.0, the working stress in tension for high-strength steels can be 50% higher. In many applications the working unit stress in tension has been 16,000 psi. for ordinary steel and it has now been increased to 24,000 psi. for high-strength steel. However, in any given application where the unit stress in tension for ordinary steel has been 18,000 psi., the unit stress for high-strength steel can be 27,000 psi. The selection depends upon the class of structure and the degree of precision in the design calculations.

Weight saving, without impairing the useful life or safety of the structure, is the outstanding advantage to be derived from the high-strength steels. Using the unit stresses in tension given in the previous paragraph, it is evident, at once, that only two-thirds as much high-strength steel is required to provide the same strength as in a member of ordinary steel; thus, another important advantage lies in the conservation of material.

The modulus of elasticity being the same for ordinary steels and high-strength steels, the influence of this property upon the strength of compression members and those in which buckling stability becomes an important consideration modifies the weight saving obtainable in tension members. Every structure is a composite of members subjected to tension, compression, shear and bending. Experience with high-strength steels in a wide variety of applications has demonstrated that the overall weight saving can conservatively be made to average at least 25%, while in some instances it reaches a percentage substantially higher.

The limitations of space permit only a brief discussion of design, and references in the bibliography should be consulted for a more adequate treatment of the subject. The following brief design specifications, based upon a yield point of 50,000 psi., will provide fundamental data for the use of high-strength steels. They correspond to specifications permitting a unit stress in tension of 18,000 psi. for ordinary steel.

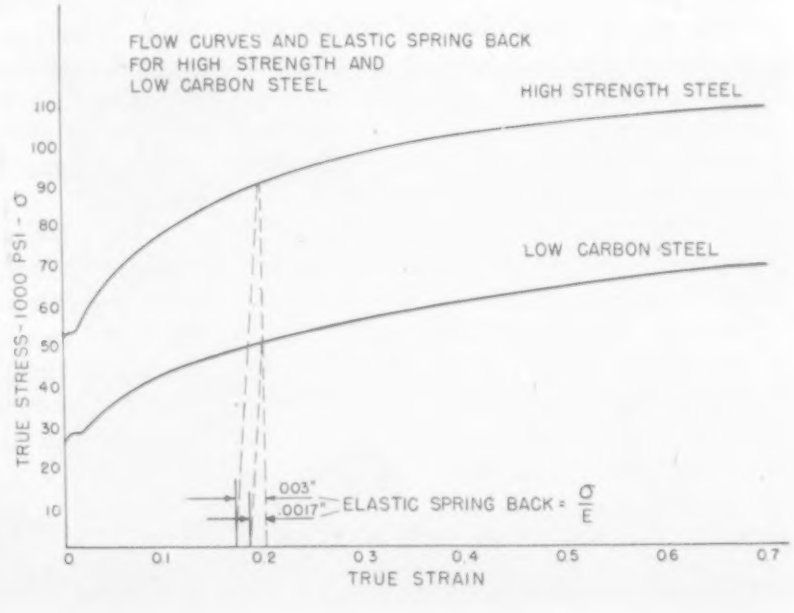


Fig. 3—Slightly more force per unit of thickness is required to attain a permanent set in high-strength steel than is needed for low carbon steel.

Design Specifications

	Lb. per Sq. In.
Axial Tenston, net section	27,000
Compression Members, centrally loaded	
Riveted Ends (L/r less than 130)	$22{,}000-0.56(L/r)^2$
Pin Ends (L/r less than 115)	$22{,}000-0.72(L/r)^2$

L=Unsupported length in in.
r=Radius of gyration in in.

Compression in extreme fibres of rolled shapes, girders and built sections subject to bending, gross section

	Lb. per Sq. In.
For $\frac{Ld}{bt}$ less than 650	$27{,}000-0.020\left(\frac{Ld}{bt}\right)^2$
For $\frac{Ld}{bt}$ over 650	$\frac{12{,}000{,}000}{\frac{Ld}{bt}}$

L=Unsupported length of flange in in.
b=Width of flange in in.
d=Depth of beam in in.
t=Thickness of flange in in.

Diagonal Tension in webs of girders and rolled beams	27,000 psi.
Shear in girder webs, gross section	17,500 psi.
Bearing on milled stiffeners and other steel parts in contact	40,000 psi.
Power-driven rivets (High Strength A.S.T.M.—A195-41)	
Shear	20,000 psi.
Bearing	40,000 psi.

Thickness of Material

In compression members, the thickness-width ratio shall not be less than 1/26 for web plates and 1/34 for cover plates.

The thickness of the webs of plate girders shall not be less than 1/135 of the clear distance between flange angles or side plates.

The elastic instability of sheets or thin flat plates is a subject which requires close attention when designing for high-strength steels. (In subsequent portions of this section, the term "plate" is used generally to cover flat material, commonly referred to as plate, sheet, or strip.) The approach is that of determining the critical load or unit stress at which buckling is imminent. The buckling of a flat plate, forming a component part of a member, (in contrast with buckling of the entire member) does not necessarily mean failure. When this occurs, often by design, the buckled portion of the plate is considered as ineffective while the remainder of the member continues to carry increasing loads. This may be illustrated as in Fig. 4, showing the cross-section of a structural member in which it is assumed that the top plate is under a compression acting longitudinally in the plane of the plate. This might occur when the plate is the compression flange of a beam or where the entire member is under compression. When a certain ratio of unsupported width to thickness of the plate is exceeded, a portion of the central region of the plate will buckle at a critical stress and thereby become ineffective.

Elastic stability will be encountered most frequently in flat plates subjected to edge compression or shear. For a flat plate in edge compression, with all the edges simply supported, the critical unit compressive stress, Scr, in lb. per sq. in., is given by the following formula:

$$Scr = \frac{2.89E}{(b/t)^2}$$

where E=Modulus of elasticity (psi.)
b=Width of plate (in.)
t=Thickness of plate (in.)

This formula is applicable so long as the value of Scr is below the yield point of the steel, at which the yield point becomes the controlling stress.

In Fig. 4 is shown a plate in edge compression in which the total compressive load, *P*, is divided between two effective widths, *w*, next to the supported edges. For simply-supported edges, the value of *w* is given by the formula:

$$w = Ct\sqrt{\frac{E}{Scr}}$$

in which C is a constant depending upon the condition of the edge supports. Values of C and maximum effective widths are shown in the following table:

Effective Width	Coefficient C	Maximum Width
w_1	0.62	b_1
w_2	0.85	$0.5b_2$
w_3	0.85	$0.5b_3$

Webs of beams and girders sub-

jected to shear may buckle under the action of the diagonal compression. The result of such buckling is to make the diagonal tension unit stress equal to twice the shearing unit stress, and does not indicate failure or weakness. In fact, airplane design is often based upon the development of this action in what is known as a "tension field" web.

Whenever elastic buckling is objectionable from the standpoint of appearance, the flat sheets are commonly stiffened with corrugations or reinforced with light stiffening elements to prevent the formation of buckles. These stiffening elements are usually cold formed angles, zees, channels or hat sections, and in many instances it is possible to utilize them as integral parts of the stress carrying members.

Structures fabricated with high-strength steels will have greater elastic deflection than those designed with ordinary steel. With the same modulus of elasticity for both grades of steel, the deflections will be proportional to the unit stresses. In most instances, the increased deflection of around 50% will not be significant, but when deflection is of vital importance and is specifically limited, it may be necessary to forego the full advantage of weight reduction. Decreases in deflection can be brought about by any one or all of the following methods:

(a) Decrease the load (equivalent to decreasing the moment)
(b) Decrease the span
(c) Increase the depth of the member

With the thinner material in high-strength steels, the extra cost of this forming operation can be justified by the weight saving thus obtained. Moreover, such corrugations (and even deliberate buckles) are often employed to break up large flat areas and give a more pleasing appearance to a structure.

Most of the high-strength steels possess added resistance to corrosion as emphasized elsewhere. Since thinner sections are made possible with the higher unit working stresses, this added corrosion resistance is a valuable asset in maintaining the service life of lightened structures. The life of many structures is definitely predicated upon the length of time elapsing before corrosion reduces the thickness of material to a point where failure occurs. This sequence period of time before failure is well established for ordinary steel, with and without copper. One method of evaluating high-strength steels, as compared to ordinary steel, is to determine the relative thicknesses prevailing at time of failure, based upon the yield points of the two grades of steel. A thickness should be added to the high-strength steel for corrosion loss, based upon the relative rates of corrosion and the thickness which was removed by this action on the ordinary steel. Usually it will be found that failure could have been prevented by proper design, frequently utilizing welding, with the consequent elimination of corrosion traps.

High strength and corrosion resistance make possible three different approaches to the problem of light weight construction.

1. To design the structure to have the same life as one built of ordinary copper steel but with a substantial weight saving.
2. To design for the least dead weight to secure the greatest economic advantages, but at the risk of a somewhat shorter service life.
3. To use the same thickness of sections as in ordinary steel and secure greater strength and longer service life.

In mobile equipment, particular interest attaches to weight reduction where any saving in dead weight can be translated into additional pay load, as for example, a truck trailer of high-strength steel weighing one ton less than a similar trailer of ordinary steel can carry one ton more of pay load.

Welded construction is well suited to achieving the aim of weight reduction. Whereas all riveting requires flanges and overlapping joints, elements to be welded can be butted together, with a consequent saving of material. Welded construction can be designed to eliminate ledges and pockets where dirt and moisture accumulate and thereby promote corrosion.

In many cases substantial weight saving can be accomplished by cold formed sections such as zees, angles, channels, etc. rather than hot rolled sections. An I-beam can be handled in one of two ways, either press two channels and connect them back to back, or build a beam, preferably by welding, comprised of a web and top and bottom flange plates. The latter method will achieve the greater weight reduction, as the use of two pressed channels involves a duplication of web material. Besides pressing substitutions for structural shapes, it is very often of advantage to press special shapes that are not obtainable as rolled sections. The possibilities in this direction are unlimited.

All designing should aim to utilize steel to the best advantage. This includes careful attention to the fabricating methods. Expensive shop operations should be eliminated wherever possible. Hot forming and the use of expensive dies can often be avoided by arrangements of material in the flat rolled condition, or by combination with formed or rolled shapes—the assembly being welded into an integral construction. Cold-formed sections should be so designed as to suit production on a pressbrake, whenever possible, as the dies are simple and relatively inexpensive.

Every design benefits from a sound stress analysis. It is the fundamental basis, and the more accurate an engineer's knowledge of the loads and stresses, the better able is he to effectively dispose the material. Many mobile structures are difficult to analyze, but modern methods of stress measurements by means of electric strain gages are furnishing much valuable information for the use of designing engineers. Structures of high-strength steel merit careful study and will be improved as attention is paid to every detail of design and fabrication.

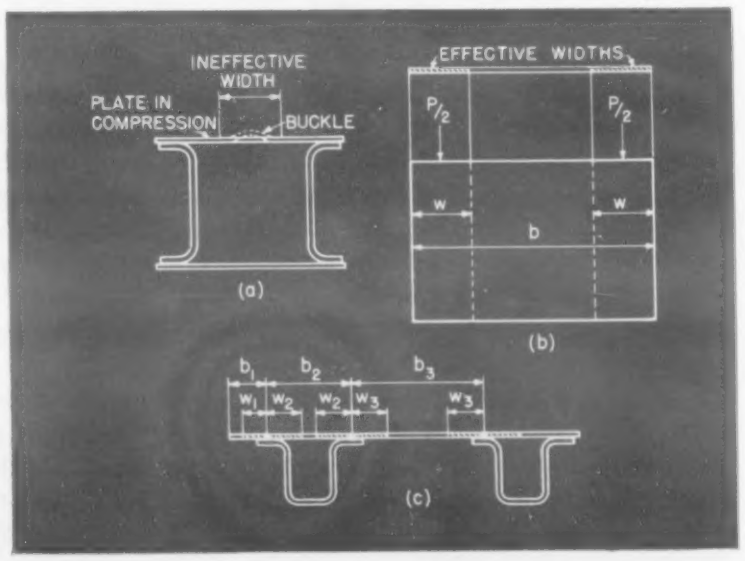


Fig. 4—Diagrams to show how to calculate unsupported widths of high-strength steel for compression members.

The output of this shovel was increased 67% by using welded high-strength steel to reduce weight of dipper and stick with a corresponding increase in load capacity from 18 to 30 cu. yd.

Applications of High-Strength Steels

The characteristics of the high-strength steels make their use economical in nearly all of the major steel consuming industries. These steels are now employed to effect weight reduction, provide longer life, and lower maintenance costs, because of their greater strength combined with superior corrosion resistance. Frequently the selection of high-strength steels is due also to the fact that they possess a combination of properties and desirable characteristics, already described, which are not available in other materials at a comparable cost.

The earliest applications were made in railroad freight and passenger cars. Approximately one-half of the production of high-strength steels has been shipped to manufacturers of transportation equipment of many and various kinds. Other important consumers are the mining, construction, earth-moving, material handling, shipping, and machinery industries.

Producers of high-strength steels have reported that about 100,000 railroad freight cars have been built with bodies employing this type of material. Dead weight has been reduced as much as 5 tons per car; the average saving being more than 2½ tons per car. Experimental hopper cars have been built with body sheets and plates of only one-half the thickness used in conventional ordinary steel design; yet, after twelve years of service, no general repairs have been required.

A noteworthy recent example of welded high-strength steel design is the Carnegie-Illinois light-weight hopper car designed by the Railroad Research Bureau of United States Steel Corp. subsidiaries. This hopper car weighs 3¼ tons less than the standard riveted design of the Association of American Railroads, and has sufficient added cubical capacity to carry 3¼ tons more coal. The Pennsylvania Railroad has recently redesigned a series of automobile cars using high-strength welded construction instead of riveted ordinary steel. The weight of the body structure was thereby reduced 9,000 pounds. Of the 4,400 railroad passenger cars ordered by domestic roads in 1945 and 1946, more than 65% were constructed largely of high-strength steel. The average weight of such equipment is about 60 tons, whereas similar equipment built of ordinary steel has previously weighed about 80 tons. In such equipment the weight saving extended throughout the structure—the bodies were so lightened that it was possible to use four-wheel rather than six-wheel trucks.

The automotive industry has made extensive use of high-strength steels in a variety of applications. Their superior properties are used to secure greater strength, or weight reduction with increased service life, in heavy trucks, trailers, and semi-trailers, gasoline truck tanks, garbage and refuse trucks, and in buses. One manufacturer of semi-trailers stated that the utilization of the high-strength steels resulted in 50% greater strength, longer life, and a weight reduction of approximately 950 lb. in a single unit. A builder of van-type trailers and truck bodies said that the application of high-strength steels resulted in a weight saving of 25% to 40%, and that this weight saving had resulted in reductions in the cost of power equipment, gasoline consumption, tires, license fees, and insurance. Passenger automobile uses include bumpers and some body parts. Steels of this type are more readily cold formed than other steels having comparable yield point and, therefore, are used for light, high-strength pressings.

In agricultural equipment, corrosion resistance is needed to provide long life under the abusive condition of exposure without protection. Furthermore, in most types of equipment, including those that are trailed, light weight is an economy. Manufacturers of farm appliances have used high-strength steels in combines, corn huskers, threshers, fertilizer spreaders, and farm wagons.

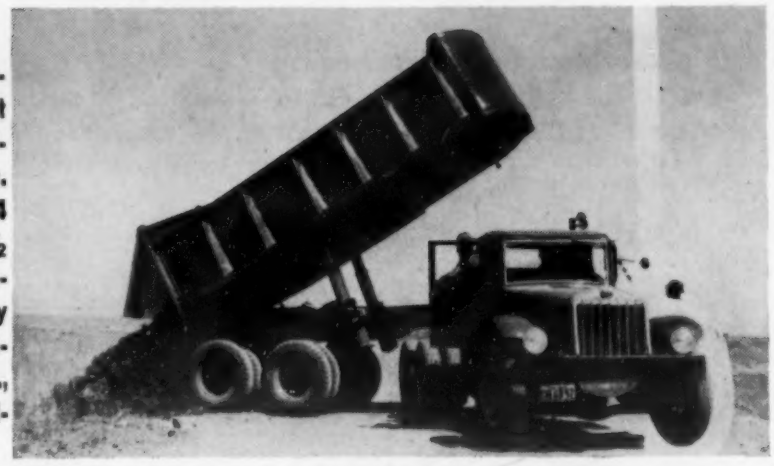
Material-handling and earth-moving equipment utilize the strength, toughness, and abrasion-resisting properties of high-strength compositions in power shovels, cranes, bulldozers, ditchers, graders, conveyors, and chutes. Power shovels provide one of the most striking examples of the advantage of weight reduction. A large electric shovel may weigh 1,200 tons or more and have a boom 100 ft. long. In one design the boom and dipper stick were made of ordinary steel and the dipper bucket of cast steel, with a capacity of 15 cu. yd. When the builder had improved the

design to eliminate weight in the boom, stick, and dipper by substituting welded high-strength steel, the shovel carried an enlarged dipper of 25 cu. yd., and the hourly capacity of the shovel was increased 76%.

Mine operators were among the first to recognize the advantage of using high-strength steel, and have now employed it in the bodies of many thousands of cars for handling coal, stone, and ore. The need for equipment that would provide exceptional sturdiness and long life led to the use of these steels in approximately the same sections as are used in similar cars built of ordinary steel. Mine equipment in which these superior steels are used to reduce weight and increase load-carrying capacity include skips, hoists, and, in some operations where grades are excessive, in car bodies. The abrasion and corrosion-resisting properties of high-strength steels have influenced their adoption in hoppers, conveyors, and screens.

Building construction does not generally provide a suitable field for high-strength steel because weight reduction in the structural members is not usually important or economical. However, in some notable instances, particularly abroad, these steels have been used in buildings, bridges, and some other large structures fabricated at home for export and erection in distant countries, the principal objectives being reduced ocean freights, and the economy of handling and erection charges at destination.

In bridges with relatively long spans, reduction in the weight of the structure itself yields substantial economy of material. Engineering societies in this country are now preparing specifications for the use of these steels in bridge construction. Satisfactory applications have been made in deck or ballast plates of railway bridges, in blast plates, and in highway bridges.



New records for moving material were set by these 16-yd. semi-trailer dump trucks. On a 6-hr. shift, 14 round trips of 8½ miles were made. High-strength, low-alloy steel in the body reduced weight 750 lb., or 12.6% over previous materials.

Numerous uses for the high-strength steels are found in machines used for building construction and road building, such as concrete and asphalt mixers, graders, scrapers, and trailers for heavy loads. The user of a trailer rack 48 ft. long built of high-strength steel stated that the pay load capacity was 40,000 lb. with a deflection in the frame of not more than 1 in. under that load, and that operating economies would amount to as much as $25.00 per day. Oil well towers and transmission towers have also been made lighter without sacrifice of strength by applying the high-strength steels.

Weight reduction in ship structures has distinct advantages from an economic standpoint. Compared with a vessel of ordinary ship steel, lighter construction of the same strength and with adequate protection against corrosion requires less power for the same speed and pay load; increased speed for the same power and pay load, or increased pay load for the same power and speed. Some of the high-strength steels have been approved for both riveted and welded construction by the American Bureau of Shipping and Lloyd's Register, for use in hull construction. The reduction in sections allowed by the classification societies below those specified for conventional construction using ship steel depends on the specific application. In general, the range is from 10 to 15%. Which of the alternate advantages mentioned above is most important, depends upon the type of vessel, cargo, and conditions under which the ship operates.

Uses which are developing for high-strength steels now include the inner bottoms, and floors, tank sides, and hatch covers of ore boats; the hulls of small vessels; barges, and accessories, such as boiler breechings, air heaters, coal bunkers, and engine deck plates.

Miscellaneous applications of high-strength steels are numerous and greatly diversified. A few, suggestive of the wide range of uses in which the special properties of these materials prove valuable, are lampposts, automobile jacks, cable reels, stokers, and air-conditioning equipment. One alert chair manufacturer reduced the weight of bus seats by 20% or 30 lb. per seat. This example is representative of many possible applications that are not immediately obvious.

Economics of Application of High-Strength Steels

The selection of high-strength steels in preference to other materials is usually based on one or more of three potential advantages: (1) minimum cost per unit of strength, (2) minimum cost per unit of service life, or (3) minimum overall cost due to operating savings and lower maintenance expense.

The first advantage is based on a high-strength-cost ratio. If the price per pound of high-strength steel is at a level of 1.50 times that of ordinary steel, the cost of tension members of two steels of equal strength will be the same. Data have been presented elsewhere indicating that a cross-section of one square inch of ordinary steel can be replaced by 0.66 sq. in. of high-strength steel. The cost ratio at present is less than 1.50 and, therefore, the high-strength steel structures will, in certain cases, cost less than equivalent structures of ordinary steel. In structures where the members are subjected to bending and compression, this weight ratio may not be so favorable to high-strength steel. However, one other favorable cost factor is that transportation charges for high-strength steel will be lower because of the smaller tonnage of steel transported. In many applications high-strength steel has cost no more than the ordinary steel displaced. Shop costs will be disregarded because elsewhere it has been shown that for various reasons they are approximately the same for both high-strength and ordinary steels.

The useful service life of many structures is determined by the corrosion resistance of the material from which

they are constructed. This relates to the second advantage resulting from the use of high-strength steel—minimum cost per unit of service life. It has been shown that some high-strength steels possess atmospheric corrosion resistance 4 to 6 times that of ordinary steel, or 2 to 3 times that of copper steel. If the life of structures can be doubled by the adoption of a superior grade of steel costing but one-half more than the grade displaced, the economy of the substitution becomes obvious. Moreover, if the life is increased only by one-half, or even somewhat less, the application will prove economical wherever labor costs are a factor of substantial importance when compared with material costs.

The third advantage provided by the employment of high-strength steel over other materials relates to the operating savings, including lower maintenance expense, which accrue to the owner of the improved modern equipment. Due to the reduction in weight made possible by these steels, the resulting savings are substantial in both mobile equipment and in machines of various types. Among the outstanding examples of such weight saving economies are modern light-weight designs of railroad freight cars; highway freight trailers, and high capacity tank trucks; general service highway trucks; truck bodies, and so on. These vehicles have one characteristic in common; namely, the maximum loaded weight is limited by the capacity of the wheels or bearings. Hence, the income producing pay load is limited to the difference between the total load limit and the weight of the vehicle. Consequently a reduction in unit weight produces an equivalent increase in the pay load that can be transported.

The maintenance expense of some of the mobile equipment which has now been operated over as much as a decade is substantially lower than that of similar conventional equipment of ordinary steel. It is too early to do more than anticipate that a similar experience will result in connection with the structures which now incorporate design and fabrication improvements to eliminate premature failures resulting from corrosion and abuse.

The value of weight reduction for these vehicles in different kinds of service has been calculated by various authorities. Prominent railroad officials have stated that the reduction of weight in an average freight car is worth 10c per lb. A study of tractor semi-trailer operations indicates that in inter-city hauls, a reduction in weight of the trailer unit of 1,000 lb. increases the annual profit approximately $450.00 per average unit. Under conditions in which the weight of the loaded vehicle approaches the maximum weight permitted on the highways of certain states, estimates of the value of weight saved approximate 50c per lb. and higher. Under certain circumstances an increase in loading capacity is not the objective sought, but rather a decrease in the weight of the vehicle itself in order to come within the maximum weight allowed on the highways of certain states, or to bring the vehicle into a lower weight classification in order to economize on license fees. In one instance such a weight reduction of the vehicle resulted in saving $125.00 in the cost of its operating license.

Increases in operating profits have likewise been obtained by using high-strength steel in earth-moving tractors; lift trucks, and numerous other types of material handling equipment.

The reduction of weight in certain parts of various machines may effect spectacular increases in output as in the case of the excavating equipment cited previously. This is true also in respect to grab buckets; crane booms; mine cages and skips. The economic advantages resulting from increased pay load due to substantial reductions in dead weight have resulted in the widespread use of high-strength steel in such equipment.

The far reaching effects of weight reduction through modern design of light-weight construction have been mentioned and may be somewhat elaborated upon. It has been demonstrated that approximately 3 tons of high-strength steel are equivalent to at least 4 tons of ordinary steel; thus, one-third more ordinary steel would be required in many structures. Putting it another way, from an equal amount of high-strength steel, 25% more units of lighter weight and sometimes of greater capacity could be built. Present steel production is inadequate to meet all demands and, therefore, the additional units which can be produced by employing high-strength steel is an effective welcome means of meeting consumer demand.

The greater significance of this increased efficiency in the use of materials lies in its salutary effect upon our rapidly depleting national resources. For every ton of ordinary steel consumption rendered unnecessary by the use of high-strength steels, our natural resources are conserved by 1.6 tons of iron ore; 1.3 tons of coal; 0.4 ton of dolomite, and 1.0 ton of scrap and other materials—a total saving of raw materials out of all proportion to the small quantities of the alloying elements consumed in the manufacture of these superior steels.

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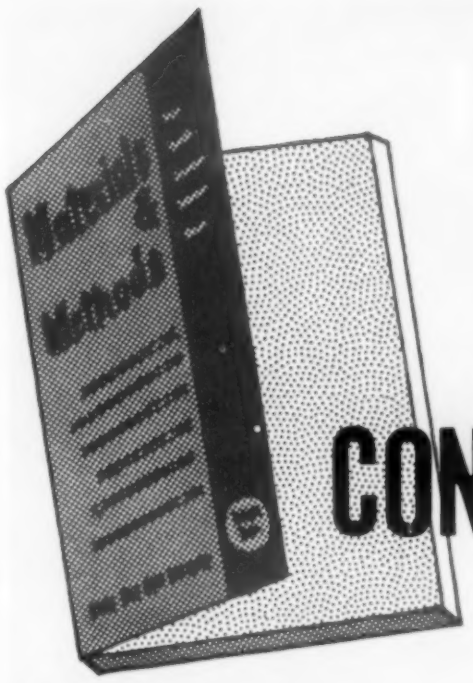

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

Specific Heat of Salts

To the Editor:

I have read the Salt Bath Manual and it reflects a great deal of work and interviews with many people. In general, I think it is a very good job, although, in my opinion, some subjects are disproportionately emphasized while some of the major fields of salt bath heat treating are dealt with very briefly.

The only real criticism I have is that the remarks regarding the importance of the specific heat of salt are absolutely meaningless and erroneous when applied to an immersed electrode internally heated salt bath. In that type of furnace the salt bath does not act as a balance wheel or heat reservoir. The time required for the bath to recover temperature is a function only of the energy being introduced into the bath by means of the electrodes. The remarks made do have some bearing when applied to externally heated salt baths since the bath in that case does act as a reservoir of heat and helps to compensate for the time lag in transferring the energy from the exterior heating chamber through the pot wall.

The Manual is studded with statements to the effect that salt bath heat treating is both widely accepted today for virtually all heat treating operations and used for mass production work, but it fails to mention what caused this situation. This state of affairs is due only to one thing—the technical and economical advantages that came with the introduction of the immersed electrode furnace design. I think mention of this significant fact should be incorporated, especially since fuel-fired salt baths have contributed very little and today utilize virtually the same designs as were in existence long before the electrode type furnace was developed.

William Adam, Jr.,
Vice President

Ajax Electric Co., Inc.,
Philadelphia, Pa.

The matter of specific heat of the salts used in salt bath treatments for metals is of rather wide interest and has been a subject of considerable debate. We are glad to have Mr. Adam's viewpoint on the matter.—The Editors.

Plating with Gold

To the Editor:

Your digest of an article on plating with gold (April MATERIALS & METHODS, p. 151) reminds me of an experience we had in trying to protect metal shaft sleeves in our "Olivite" rubber lined pumps from corrosion by ferric chloride back in the 20's.

Our pumps had all parts in contact with the ferric chloride protected by rubber except the shaft sleeve running in an acid resistant packing. The customer told us that gold was the only metal that could be used.

He did not propose to pay for solid gold shaft sleeves so we made the sleeves of Illium, which was our standard for other acids at that time and paid $20 each for plating three sleeves with a heavy deposit of gold.

When the pumps started in the customer's plant we got a telegram saying the gold was gone and sleeves being attacked after three hours service. We took the pumps back and eventually solved the problem by using sleeves made from mechanical porcelain.

Since then we have never tried plating for corrosion resistance. We are sending you two copies of this letter so you can send one to the author if you desire. He should emphasize that he means for "moderate service."

E. H. Herbert,
Engineering Department

Oliver United Filters Inc.,
Oakland 1, Calif.

Our thanks to Mr. Herbert for his interesting observations—The Editors.

NUMBER 144
July, 1947

MATERIALS: Stainless Steel

Resistance of Several Stainless Steels to Various Corrosive Media

Various factors affect the corrosion resistance of materials such as aeration, agitation and temperature. Thus, this listing should be used as a guide rather than as a final recommendation.

Symbols: S — Satisfactory U — Unsatisfactory

Media	Concentration	Temp. F	304-347	316	410	430
Acetic Acid	All	70	S	S	S	S
Acetic Acid	Over 15%	Boiling	U	S	U	U
Acetic Anhydride	All	Any	S	S	S	—
Acetone	All	Any	S	S	—	—
Acid Mine Water	—	Cold	S	S	—	S
Alcohol, Ethyl	All	Any	S	S	—	S
Alcohol, Methyl	All	70	S	S	—	S
Alcohol, Methyl	All	150	U	S	—	U
Alum	Up to 10%	Any	S	S	—	U
Alum	Sat. Sol.	70	—	—	S	—
Ammonia	All	70	S	S	S	S
Ammonia	Gas	Hot	U	—	U	—
Ammonium Chloride	10-50%	Boiling	U	U	—	—
Ammonium Chloride	Sat. Sol.	70	—	—	S	—
Ammonium Sulfate	1 and 5%	70	S	S	S	S
Ammonium Sulfate	10%	70	—	—	S	—
Ammonium Nitrate	All	All	S	S	—	S
Ammonium Nitrate	Sat. Sol.	Boiling	—	—	S	—
Beer	—	—	S	S	—	—
Benzol	—	Any	S	S	—	S
Benzol	Sat. Sol.	70	—	—	S	—
Benzoic Acid	All	70	S	S	—	S
Blood	—	70	S	S	—	S
Calcium Chloride	All	Hot	U	U	U	U
Calcium Hypochlorite	2%	70	S	S	—	S
Carbolic Acid	All	Any	S	S	—	—
Carbolic Acid	—	70	—	—	S	—
Carbon Tet.	Pure	70	S	S	S	S
Chloroacetic Acid	Any	All	U	U	U	U
Chlorine Gas	Dry	70	U	S	U	U
Chlorine Gas	Moist	70	U	U	U	U
Chromic Acid	5%	70	S	S	U	S
Chromic Acid	50% Commercial	Boiling	U	U	U	U
Citric Acid	5%	70/150	—	—	S	—
Citric Acid	Up to 15%	Any	S	S	—	S
Coffee	—	Boiling	S	S	—	S
Copper Sulfate	5%	70	S	S	S	S
Copper Sulfate	Sat. Sol.	Boiling	S	S	U	—
Creosote (Coal Tar)	—	Hot	S	S	—	—
Creosote Oil	—	Hot	S	S	—	—
Ferric Sulfate	5%	70	S	S	S	S
Ferrous Sulfate	Dil. Sol.	70	S	S	S	S
Formaldehyde	40% Sol.	70	S	S	S	S
Formic Acid	Up to 5%	Up to 150	S	S	U	U
Fruit Juices	—	70	S	S	—	S
Fuel Oil	Acid-Free	Hot	S	S	—	—
Fuel Oil	Sulfuric Acid Present	Hot	U	S	—	—
Gasoline	—	Any	S	S	—	S
Glue	All	Any	S	S	—	—
Hydrochloric Acid	All	Any	U	U	U	U

Symbols: S — Satisfactory U — Unsatisfactory

Media	Concentration	Temp. F	304-347	316	410	430
Hydrofluoric Acid	All	Any	U	U	U	U
Hydrogen Peroxide	All Acid-Free	Any	S	S	S	S
Ink (Acid-Free)	—	70	S	S	—	—
Iodine	All	Any	U	U	U	U
Kerosene	—	70	S	S	—	S
Lactic Acid	Up to 5%	Up to 150	S	S	U	S
Lactic Acid	10%	Boiling	U	S	—	—
Magnesium Chloride	1-5%	70	S	S	—	U
Methanol	—	70	S	S	S	S
Milk	—	Hot and Cold	S	S	—	S
Molasses	—	—	S	S	—	S
Naphtha	—	70	S	S	—	S
Nitric Acid	All	70	S	S	—	S
Nitric Acid	Conc.	Boiling	U	U	U	U
Oils, Crude	Acid-Free	Hot and Cold	S	S	—	S
Oils, Mineral & Vegetable	Acid-Free	Hot and Cold	S	S	—	S
Oleic Acid	—	70	S	S	S	S
Oxalic Acid	5%	70	S	S	S	S
Oxalic Acid	10%	70	S	S	—	—
Oxalic Acid	10%	Boiling	U	U	U	U
Phosphoric Acid	10%	70	U	S	U	U
Sauerkraut Brine	—	—	S	S	U	U
Sea Water	—	—	S	S	U	U
Sewage (Acid-Free)	—	—	S	S	—	—
Soap	—	70	S	S	—	S
Sodium Bicarbonate	All	Any	S	S	—	S
Sodium Carbonate	5%	Any	S	S	—	S
Sodium Carbonate	10% Sat. Sol.	70/120	—	—	S	—
Sodium Chloride	5%	150	U	S	—	U
Sodium Nitrate	—	Fused	U	S	U	U
Sodium Sulfate	5%	70	S	S	S	S
Sodium Sulfate	All	70	S	S	U	U
Sodium Sulfide	Sat. Sol.	—	U	S	—	U
Sodium Sulfite	5%	70	S	S	U	U
Stearic Acid	—	—	S	S	S	S
Sugar Beet Juice	—	—	S	S	—	S
Sugar Juice	—	—	S	S	—	S
Sulfuric Acid	5%	70	U	S	—	U
Sulfuric Acid	50%	Any	U	U	—	U
Sulfuric Acid	Conc. Sol.	70	S	S	S	S
Sulfurous Acid	Sat.	70	U	S	U	U
Tannic Acid	All	Any	S	S	—	S
Tar	—	70	S	S	—	—
Varnish	—	Any	S	S	—	—
Vegetable Juices	—	—	S	S	—	—
Vinegar	—	70	S	S	—	S
Wine	—	All	S	S	—	S
Wood Pulp	—	All	S	S	—	—
Wort	—	All	S	S	—	—
Yeast	—	All	S	S	—	—

Prepared from data submitted by the Lukens Steel Co.

AN IMPORTANT ANNOUNCEMENT

ABOUT

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SERVING INDUSTRY . . . WHICH SERVES MANKIND

NUMBER 145
July, 1947

MATERIALS: Felts

Industrial Felts

This File Fact is intended to supplement File Fact No. 45 which appeared in the March, 1945 issue of METALS AND ALLOYS (Vol. 21, No. 3, p. 741). Together these two will furnish a ready reference on the standard specifications, colors, weights, properties, relative costs, standard sizes and "machinability" of both roll and sheet wool felts for industrial uses (sometimes these are called "mechanical felts").

Table 1—Summary of SAE Specifications for Roll Wool Felts and Standard Commercial Sizes

SAE Spec. No.	Trade Designation	Actual Wool Content, % (Min.)	Percent Soluble Material			Breaking Strength, Psi. (Min.)	Splitting Strength, Lb. (Min.)[1]	Standard Thicknesses (Nominal), In.[2]	Standard Roll Width, In.[2-3]
			Soluble in Carbon Tet. (Max.)	Soluble in Water (Max.)	Comb. Water and Carbon Tet. Soluble (Max.)				
F-1	Back check	95	2.5	2.5	4.0	500	33	(1/16),1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,7/8,1)	60
F-2	Back check	95	2.5	2.5	4.0	500	30	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	60
F-3	Back check	90	2.5	3.0	4.5	400	24	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	60
F-5	Extra firm pad	95	2.5	2.5	3.0	400	18	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	60 (72)
F-6	Extra firm pad	92	2.5	2.5	4.5	275	16	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	72 (60)
F-7	Extra firm pad	80	3.0	4.0	7.0	250	12	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4)	72
F-10	Firm pad	95	2.5	2.5	3.0	225	8	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4)	72
F-11	Firm pad	92	3.0	2.5	4.5	200	6	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	72
F-12	Firm pad	85	4.0	2.5	6.5	100	3	1/8,3/16,1/4,5/16,3/8,1/2	72
F-13	Firm pad	75	4.0	4.0	8.0	75	2	1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	72
F-15	Firm pad	55	4.0	5.0	9.0	75	2	(1/16),1/8,3/16,1/4,5/16,3/8,1/2,(5/8,3/4,1)	72
F-26	Soft pad	45	8.0	6.0	14.0	—	—	(1/8),3/16,1/4,5/16,3/8,1/2,(3/4,1)	72
F-50	Ball bearing felt	95	2.5	2.5	3.0	500	—	0.050,0.055,0.060,0.065,0.070,0.075, 0.080,0.085	60 (72)
F-51	Ball bearing felt	92	2.5	2.5	4.5	300	—		60 (72)
F-55	Ball bearing felt	75	4.0	4.0	8.0	200	—		60 (72)

[1] *Splitting strength tests applicable to felts having a minimum thickness of 3/16 in.; for felts less than 3/16 in. in thickness, a test of breaking strength only is recommended.*

[2] *The standard thickness (nominal) and roll widths of felts made by the leading manufacturers are listed; sizes regularly listed by a few manufacturers outside these common sizes are given in parentheses.*

[3] *Roll felts are usually fabricated in 15 to 45 yard lengths (depending upon the grade and thickness of the material).*

Table 2—Standard Sheet Wool Felts—Qualities and Sizes

Type[1]	Grade[2]	Standard Thicknesses (Nominal), In.	Standard Sheet Size, In.
12-S	1, 2, 3 and 4	1/4,3/8,1/2,5/8,3/4,7/8,1, 1 1/4,1 1/2,1 3/4,2,2 1/2,3	36 x 36
16-S	1, 2, 3 and 4	1/4,3/8,1/2,5/8,3/4,7/8,1, 1 1/4,1 1/2,1 3/4,2,2 1/2,3	36 x 36
20-S	1, 2, 3 and 4	1/4,3/8,1/2,5/8,3/4,7/8,1, 1 1/4,1 1/2,1 3/4,2,2 1/2,3	36 x 36
26-S	1, 2, 3 and 4	1/4,3/8,1/2,5/8,3/4,7/8,1, 1 1/4,1 1/2,1 3/4,2,2 1/2,3	36 x 36
32-S	1, 2, 3 and 4	1/4,3/8,1/2,5/8,3/4,7/8,1, 1 1/4,1 1/2,1 3/4,2	18 x 36

[1] *The type numbers (standardized by the Felt Association, Inc.) indicate the weight (in lb. per sq. yd.) of nominal 1-in. thickness. (The standard classifications are written, 12-S-1, 16-S-4 or 32-S-2.)*

[2] *The standard grades and the meaning of each grading follows: Grade Description: 1. Sheet felts made of highest quality white wools. 2. Made of selected unbleached wools. 3. Composed of selected and reused wools; may be gray, natural or colored. 4. Made of new, reprocessed or reused wools and other vegetable or animal fibers.*

Table 3—Relative Cost of Various Standard SAE Felts

SAE Spec. No.	Relative Cost Based Upon SAE F-5 as 100[1]	SAE Spec. No.	Relative Cost Based Upon SAE F-5 as 100[1]
F-1	136	F-10	59
F-2	69	F-11	35
F-3	64	F-12	28
F-5	100	F-13	22
F-6	52	F-15	19
F-7	42	F-26	12

[1] *These figures are based on the comparative costs of 3-in. O.D. x 2-in. I.D. x 1/4-in. thick washers made of the various standard types of felt.*

Table 4—Tolerances of Punched Disk or Washer Diameters

SAE Spec. No.	Outside Dia., In.	Tolerances of O.D. for Various Thicknesses of Felt, In.[1]			
		1/8-in. Thick	1/4-in. Thick	1/2-in. Thick	3/4-in. Thick
F-1, F-2, F-3	1/8-1	±0.003	±0.006	±0.009	±0.012
	1 1/8-2	±0.006	±0.009	±0.012	±0.015
	2 1/8-3	±0.009	±0.012	±0.015	±0.018
	3 1/8-4	±0.012	±0.015	±0.018	±0.021
	4 1/8-5	±0.015	±0.018	±0.021	±0.024
	5 1/8-6	±0.018	±0.021	±0.024	±0.027
F-5, F-6	1/8-1	±0.004	±0.009	±0.010	±0.013
	1 1/8-2	±0.007	±0.011	±0.013	±0.016
	2 1/8-3	±0.010	±0.013	±0.016	±0.019
	3 1/8-4	±0.013	±0.016	±0.019	±0.022
	4 1/8-5	±0.016	±0.019	±0.022	±0.025
	5 1/8-6	±0.019	±0.022	±0.025	±0.028
F-10, F-11, F-13, F-15	1/8-1	±0.005	±0.009	±0.013	±0.017
	1 1/8-2	±0.009	±0.013	±0.017	±0.021
	2 1/8-3	±0.013	±0.017	±0.021	±0.025
	3 1/8-4	±0.017	±0.021	±0.025	±0.029
	4 1/8-5	±0.021	±0.025	±0.029	±0.033
	5 1/8-6	±0.025	±0.029	±0.033	±0.037
F-26	1/8-1	±0.006	±0.012	±0.018	±0.024
	1 1/8-2	±0.012	±0.018	±0.024	±0.030
	2 1/8-3	±0.018	±0.024	±0.030	±0.036
	3 1/8-4	±0.024	±0.030	±0.036	±0.042
	4 1/8-5	±0.030	±0.036	±0.042	±0.048
	5 1/8-6	±0.036	±0.042	±0.048	±0.054

[1] *When punching washers the wall thickness (one-half the difference between O.D. and I.D.) should not be less than 1/4 in. for soft felts (such as SAE F-10, F-11, F-12, F-13, F-15 and F-26), or less than 1/8 in. for the harder felts (SAE F-1, F-2, F-3, F-5 and F-7).*

Information regarding standard industrial felts was furnished by the following companies:
The Felt Association, Inc., New York 19, N. Y.
American Felts Co., Glenville, Conn.
The Felters Co., Boston, Mass.
Western Felt Works, Chicago 23, Ill.
The Booth Felt Co., Brooklyn, N. Y.

Compiled by Robert S. Burpo, Jr.

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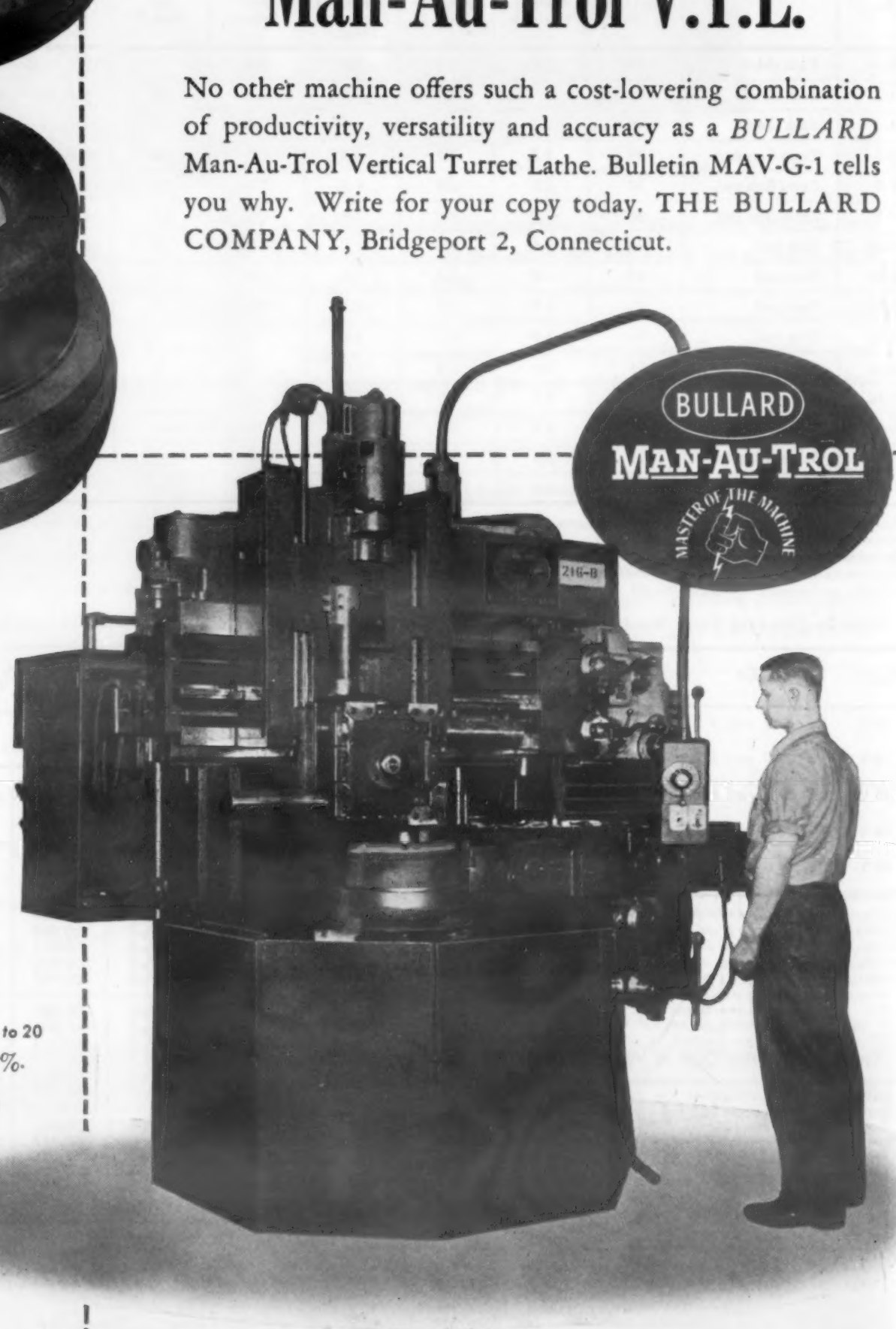

Here are shown before and after shots of a cast iron drive wheel for a Motor Grader, machined on a 30" *BULLARD* Man-Au-Trol Vertical Turret Lathe by Austin-Western Company, Aurora, Illinois. The former method, employing *two machines*, took *1 9/10 hours*. On the *BULLARD* Man-Au-Trol V.T.L., *actual cutting time was reduced to 20 minutes*... a time saving of 82.4%.

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MATERIALS & METHODS

DIGEST

A selective condensation of articles—presenting new developments and ideas in materials and their processing—from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

A High Creep Strength Austenitic Steel for Gas Turbines

Condensed from "Metallurgia"

An outline of the early work that led to the development of G.18B for gas turbine disks is given. Various modifications of the valve steel containing 13 chromium, 13 nickel and 2% tungsten were tested. The results indicated that many factors needed investigation, particularly the effect on creep strength of small quantities of some elements. Unfortunately, the first modifications with reasonable creep strength showed low ductility. This property could be appreciably increased by lowering the chromium content. The drop in impact value after long holding at 1200 F could best be avoided by the addition of approximately 0.15% columbium.

The final outcome of this research was G.18B containing 0.4 carbon, 0.8 manganese, 1.0 silicon, 13 chromium, 13 nickel, 10 cobalt, 3 columbium, 2 molybdenum and 2.5% tungsten. A solution treatment at 2370 F is used. The low room temperature proof strength can be increased by aging for 20 hr. at 1470 F, but this treatment decreases the creep strength a little. Warm-working at 1200 to 1470 F raises the proof strength significantly without sacrifice of the creep strength.

Warm worked disk material shows the following room temperature mechanical properties:

0.2% proof strength, psi.	62,720
Tensile strength, psi.	107,520
Elongation, % in L=4 A	12
Reduction of area, %	15

The stress rupture and creep strength values are:

Temperature, F	Stress for Rupture in 1000 Hr. Psi.	Stress for 0.5% Creep in 1000 Hr. Psi.	Stress for 0.2% Creep in 1000 Hr. Psi.
1200	35,840	22,400	17,920
1290	25,760	15,680	—
1380	16,800	12,990	8,960
1470	12,770	10,750	9,400

NOTE: The values for 0.2% creep are correct; 1380 and 1470 values are *not* interchanged.

The alloy G.18B has been found for most design purposes to have adequate creep, fatigue and impact strength at high temperatures. The presence of adequate ductility and toughness with a high creep strength meets normal engineering demands. Better steels and alloys will surely become available during the next few years, and some are already well advanced in development. (D. A. Oliver & G. T. Harris. *Metallurgia*, Vol. 35, Mar. 1947, pp. 235-238.)

Plastic Mold Cavities Made of Powdered Metal

Condensed from a Paper of the Society of the Plastics Industry

Plastic mold cavities made by pressing powdered iron against the face of a hob have been made for quite some time on an experimental basis. The process used in the manufacture of powdered metal cavities for plastic molds is very similar to that used in the production of powdered metal gears, cams, and other machine parts. The process requires considerable care and delicate manipulation of high pressures on the order of 30 to 90 tons per sq. in.

An electrolytic iron powder is used as the raw material. This powder is placed in a die that forms the outside surface of the cavity. The bottom punch or hob upon which are engraved or machined the details which are to be transferred to the inside of the cavity must fit the die to within 0.0005 in. Top and bottom pressure is applied to the powder in the die with the aid of a top punch, which is also custom built to a gage fit.

After the powder has been compressed into a compact so that the design of the hob has been clearly transferred to the cavity, the compact is sintered, coined, resintered and recoined several times to accentuate the details in the cavity and to increase the ductility and strength of the compact. The sintering or furnace heating is done in a carefully controlled atmosphere. Hydrogen is usually used.

The sintered and coined cavity thus formed is carburized and hardened by any of the conventional hardening techniques to an average case depth of approximately 1/32 in. Rockwell hardness values up to C-60 are obtained on the case and C-25 on the core. If it is assumed that 50 tons per sq. in. are used as the briquetting and the coining pressures, a density of 7.63 or 3% porosity would result in the powdered metal compact after the fourth coining. The traverse strength of this powdered metal cavity is 130,000 psi. as compared with 300,000 psi. for the steels used in hobbed cavities. The tensile strength of the powdered metal cavity is about 50,000 psi.; the tensile strength of the steel hobbed cavity averages 120,000 psi.

Certain designs such as thin sections and raised points which are difficult to hob can be produced in powdered metal cavities. The more expensive tooling and greater care required in fabricating the weaker powdered metal cavity makes it impractical to use powdered metal except for high production and impossible hobbing jobs. The cost of powdered metal cavities cannot be economically amortized over the usual low production run, which is the backbone of the plastic cavity business.

Although the surface finish of powdered metal cavities is fair, it cannot be compared with the better finish of cavities made by the hobbing or machined method. (E. R. Walter. Paper, *Soc. Plastics Industry*, May 9, 1947 Meeting, 4 pp.)

DIGEST

Joining Ceramics and Metals by Soldering

Condensed from a Report of the Office of Technical Services

A simple, efficient process for soldering ceramics and metals together was developed in Germany during the war. The process was used in the manufacture of electronic decimeter tubes for continuous wave oscillators, radar transmitters, and high frequency and superheterodyne receiver amplifiers.

The soldering process made it possible to construct vacuum-tight tubes of ceramic and metal materials. Such construction had the following advantages: (1) Simplified the assembly of multi-element electrodes and grids. (2) Facilitated the compact and precise location of axial-symmetrical elements. (3) Permitted mass production with the use of unskilled help. (4) Expedited the formation of high vacuums.

The ceramic parts of the decimeter tubes were made of talcum or magnesium silicate, mixed with small amounts of China clay, zirconium dioxide, and potassium feld spar. The metal parts were an alloy of either 54 iron and 45% nickel, or 58 iron and 42% nickel.

To simplify the soldering process, the points at which the ceramic parts made contact with the metal parts were coated with molybdenum-iron parts and then with nickel powder solution. For similar reasons, appropriate sections of the metal parts were nickel-plated and then silver-plated. Pure silver was used for soldering the ceramic and metal surfaces together. (Eugene D. Reed. Paper, *Office Tech. Services.*)

Zinc Alloy Tools for Blanking, Piercing and Forming Sheet Metal

Condensed from "Sheet Metal Industries"

The use of zinc alloy drop hammer dies came to prominence in the production of aircraft sheet metal parts where they seemed the most economical solution to the problem of small quantities and good production. The use of zinc proved to be most satisfactory due to the ease with which it can be cast; also, owing to its softness, hand finishing and machining are readily carried out with a minimum of equipment. Moreover, the zinc can be recovered when the tools become obsolete.

It is much cheaper to cast drop hammer punches and dies than to machine them. The tool designer has the choice of cast iron, Meehanite, or zinc alloys. Accurately cast zinc alloys can be hand finished more quickly than other materials after they come from the die sinking machine. The technique of manufacturing patterns in plaster of Paris proved highly economical in cost and time, and the necessary accuracy was more easily obtained than with wood.

In the early days, straight zinc was used for the dies, usually in conjunction with antimonial lead for the punches. The latter is still sometimes used for aluminum but is not satisfactory for harder materials. Higher strength zinc alloys are now used most extensively.

Since wood form blocks were not completely satisfactory for stretcher presses, the blocks are now made up from plaster patterns and cast in zinc alloy. In addition to the saving in costs, the zinc has a much lower coefficient of friction when well lubricated than does wood.

Zinc alloy dies have also been used in a hydraulic press for the production of motor body panels. The small quantity of pressings required and the short time available for their manufacture suggested the use of zinc rather than cast iron.

Zinc alloys have been used for blanking dies. The punch is made of 3% nickel case hardening steel while the die is made from zinc alloy plate. Despite many experiments, the zinc alloy blanking dies are not recommended for steel thicker than 30 s.w.g. even when the expected die life is short. With light alloys, however, these tools are standing up well for gages up to 16. The introduction of this type of blanking die has revolutionized the speed of putting new parts into production. (J. W. Sladden & H. S. Walker. *Sheet Metal Ind.,* Vol. 25, Mar. 1947, pp. 567-581, 586.)

Nickel Chromium Alloys for Gas Turbine Service

Condensed from a Paper of The American Society of Mechanical Engineers

Practical nickel-base alloys have been developed which are useful in gas turbine work for temperatures up to at least 1500 F. One of these, Inconel "X," has the following analysis: 73 nickel, 0.04 carbon, 0.50 manganese, 0.40 silicon, 15.0 chromium, 1.0 columbium, 2.5 titanium, 0.70 aluminum and 7.0% iron. The alloy has a high rupture strength at all temperatures up to 1500 F. It shows low creep rates under high stresses at 1200, 1350 and 1500 F; it has high strength at room temperature, which is a result of composition and heat treatment and not so-called "hot cold work." This is a distinct advantage in forging of any considerable size, such as a gas turbine rotor wheel, because it is not easy to procure uniform properties throughout a large section by cold work.

Inconel "X" compares favorably in strength at gas turbine temperatures with many alloys containing larger amounts of less plentiful or costly elements. It is a practical mill product available in billets, single rod selections, wire, sheet and strip.

Inconel "W" is of almost the same composition as Inconel "X" except that it contains no columbium. It has about 80% of the strength of Inconel "X" at room temperature and up to 1200 F. However, at 1500 F it has less than half the stre of Inconel "X".

These two alloys may be forged, and worked best between 2225 and 1800 They can be machined provided suit slowdown and regulation of cut is m as is required on any material of sim strength and toughness. They can be we by arc, resistance, gas or shielded methods. Problems arise in welding to o alloys, but progress in this direction being made.

A casting alloy has also been develo which is primarily suited for exte service applications requiring high cr resistance around 1500 F. The alloy good casting qualities and is resistant thermal shock. A typical analysis is: nickel, 20 chromium, 0.5 carbon, manganese, 0.6 silicon, 0.6 columbi 0.25 titanium, 0.025% calcium. The a is solution treated by water quenchi from 2300 F, and is usually aged at 1 F for 12 hr. followed by 18 hr. at 1500 It was originally developed to meet Bureau of Ships' requirements for turbine material. (C. A. Crawford. Pa No. 46-A-73, *Am. Soc. Mech. Engrs.,* D 1946 meeting. 15 pp.)

Lead Improves Aluminum-Magnesium Alloys

Condensed from "Aluminum-Archiv"

Small additions of lead to an alumin alloy containing 8% magnesium impro some of this alloy's service properties well as its machinability. It was found th a maximum of 3% lead can be alloyed w the aluminum alloy and that with the me ing and casting practice used, no segregati was found with lead contents up to 2.5% The introduction of the lead before or af the addition of magnesium had no effect o the uniformity of distribution of the le

The only effect of lead on the tensi properties was found in a decrease in th elongation. The fatigue strength of the a loy with about 2.5% lead was 21,35 to 22,760 psi. for bars and 11,380 psi. fo notched specimens. The lead containi alloys work hardened less rapidly than th lead free alloy. The heterogeneity of th cold worked alloy was increased by heati at 300 to 480 F. The alloy was complete softened by heating at 570 F.

A short chip is needed for good fre machining properties. A lead addition o about 1.25% had a significant effect in pro ducing a short chip. A further increase i the lead content caused only a slight chang in the chip form. Cold working had deleterious effect on the chip formation. heterogenizing treatment at 390 to 480 F or a homogenizing treatment above th melting point of lead at about 660 F ha a favorable effect on the chip size.

The heterogenizing treatment, which is also used to improve the machinability o the commercial 8% magnesium alloy, causes the precipitation of finely divided particles of Al_2Mg_3. The beneficial action of the homogenizing treatment is due solely to the lead inclusions. The surface finish of the lead bearing alloy was excellent.

Long salt spray tests indicated that the corrosion resistance of the free machining alloy was practically equivalent to that of the lead free alloy. (H. Bauer. Doctor's Thesis for the Technische Hochschule at Aachen, Germany; also abstracted in *Aluminum-Archiv*, Vol. 24, 1939.)

Technical Developments in Germany and Japan During the War

Condensed from Papers of the Office of Technical Services

The following reports on technical developments in Germany and Japan during the war have recently been issued by the Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

German Metals Research

Shortages of such strategic materials as nickel, chromium, manganese and vanadium, largely influenced the direction of German metallurgical research. Although their research facilities were well-designed and in spite of the urgent need for substitute materials and processes, wartime research produced few spectacular results. However, a great deal of the research in basic metallurgical problems should prove useful to investigators in this country. The Kaiser-Wilhelm Institute for Iron Research was the major metals research organization. Some of the subjects investigated were: production of fatigue and heat resistant steel alloys, electro-chemical polishing, mechanical properties of steels, steel treatment and manufacturing technology, and powder metallurgy. (PB-42746, German Metallurgical Laboratories, 101 pp.)

Anodes for Electroplating

The quality of electroplating is greatly influenced by the size and shape of anodes and the method of manufacturing. These factors, as well as the purity and susceptibility to polarization or formation of slimes and crusts, are just as important as electrolytes and other constituents in determining the success of galvanic systems. The report discusses the correct use of copper, brass, nickel, chromium, zinc, cadmium, tin, lead and gold anodes. (E. R. Thews. PB-47010, Anodes.)

Metals in Japanese Electronic Tubes

Shortages of nickel and molybdenum caused Japanese engineers to investigate iron for vacuum tube parts. Pure degassed iron was found to have durability and electron emission characteristics comparable to those of molybdenum and nickel. The production process was tedious and costly. Iron sand was the raw material. It was reduced in an electric arc furnace and the iron metal drawn off. The metal was then melted in a high frequency electric induction furnace and deoxidized with silicon and aluminum. For small electron receiving tubes the iron contained less than 0.02% oxygen. For some large power tubes the content was less than 0.004%. (W. Jorgensen. PB-49839, Japanese Electronic Tubes, 35 pp.)

Sintered Plates for Batteries

Sintered plates were developed by the Germans for nickel-cadmium alkaline batteries. Because of their porosity, the sintered plates did away with the need for a grid structure of tubes or pockets to hold the active anodic or cathodic material. The active material was deposited directly into the pores of the plates by an electrolytic process. The sintering powder for the positive base plate consisted of pure carbonyl nickel; and for the negative plate, a mixture of 30% carbonyl nickel and 70% copper. (G. B. Ellis. PB-53491, General Survey of German Battery Industry, 4 pp.)

Steel Wire Manufacturing

Electro-galvanizing of heat-treated steel wires for wire rope was experimented with for several years in a specially designed German plant. It was found that this method was considerably more expensive than hot dipping; also, the hot dipped wires had greater resistance to corrosion because of the formation of an iron-zinc alloy layer which is not formed in the electro-galvanizing process. A unique electro-magnetic device was used in some plants to locate either external or internal broken wires. The testing unit had two field coils and a probing coil connected to a galvanometer. The steel rope was run through the electrified field coils and the galvanometer's reaction recorded on a continuous film. A broken wire caused a major deflection of the galvanometer. (J. C. Richards. PB-49242, Steel Wire: Notes on German Wire Drawing and Steel Rope Manufacture, 40 pp.)

Supersonic Testing

Supersonic testing methods similar to those developed in this country were used in Germany during the war to locate bubbles in sheet metal. The equipment described in the report uses the through-transmission method. Supersonic vibrations are generated by a quartz crystal and transmitted by a metal block to a narrow chamber of running water. The vibrations pass through the test piece, placed in the water, and are received on the other side by a crystal receiver. The report also describes briefly X-ray inspection and the use of Geiger-Mueller counters to measure wall thicknesses. (G. J. Thiessen. PB-25556, The Non-Destructive Testing of Materials and X-ray Protection Methods, 8 pp.)

New Cold Drawing Process for Magnesium Alloys

Condensed from "Metals Technology"

Magnesium and its alloys are generally considered to have limited deep-drawing characteristics at room temperature. The magnesium alloy containing +1.5% manganese (designated as AM_3S, or Dow "M" or ASTM No. 11) was subjected to a series of deep-drawing tests to determine whether its cold-drawability at room temperature could be improved.

Two methods of loading for drawing the blanks were used, *i.e.*, continuous and intermittent. In the continuous process the load was continuously applied and increased until the operation was completed. In the intermittent process, the load was applied for some time interval until a given value was attained and then released. The cycle was repeated with progressive increase in load values until the operation was completed.

The results of the work showed conclusively that the deep drawability of the magnesium alloy can be greatly improved by the intermittent process. The maximum drawability with the intermittent process is around 40% as compared with 25% for the continuous method.

Similar advantages can be expected with other magnesium alloys, since basically they all have the same type of crystallographic structures and deform according to the same mechanisms of plastic flow.

This new process of intermittent application of load for deep drawing may also be used to improve deep-drawing performances over a wide temperature range, especially where the plastic flow proceeds mostly by a twinning action.

Along with the increased cold drawability of the magnesium alloys, great increases have been found in the hardness. Under this condition, higher tensile values can be expected which will contribute to a greater weight-strength advantage, characteristic of magnesium alloys. (L. A. Carapella & W. E. Shaw. *Metals Technology*, April 1947, Tech. Paper No. 2149, 8 pp.)

Large Injection Molded Plastic Parts

Condensed from a Paper of the Society of the Plastics Industry

The demand for large injection molded plastic parts has increased considerably during the past year. High-speed production methods have extended the usefulness of molded thermoplastic materials into many new product applications. One of the most attractive features of these materials is the wide range of color possibilities. Since the color is inherent in the material, all spraying and finishing problems are eliminated.

Large thermoplastic parts usually are appreciably lighter than similar parts in other materials. In general, they are lower in specific gravity and, because of their tougher nature, can be molded in much thinner sections. Parts can also be produced with intricate designs which are faithfully reproduced in this type of molding.

Large injection molded parts should be designed so as to facilitate the flow of the material and allow the mold to fill evenly. Breaking up the flow of the material may cause weld lines or trapped air in the part.

Heavy sections should be avoided where possible as these tend to cause sink marks and slow up the molding cycle. Care must

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DIGEST

be exercised to eliminate any undercuts in the molding of polystyrene material where generous draft should be provided to facilitate ejection of the part. Some of the softer non-rigid materials can be molded with undercuts designed into the part where this is desirable.

Usually all large molded parts show flow marks or blemishes of some type and, therefore, all parts should be designed so that all flat surfaces are slightly convex or decorated with some type of design to improve the appearance of the molded piece.

The present shortages of thermosetting plastics has led manufacturers to investigate the use of thermoplastics for large parts such as radio cabinets. Other applications for large injection molded parts are found in the electric refrigeration field. Here freezer chest doors, drawer pulls and breaker strips have been molded.

There has also been a large demand in nursery applications for such things as training seats, dishes, cups and toys. Applications are also being developed in many new fields which heretofore had seldom been considered.

The cost of thermoplastic materials is somewhat higher; however, a greater number of parts are produced from each cavity on an injection mold than from a similar compression mold. This, together with the variety of colors and thinner wall sections used, makes large thermoplastic parts competitive and desirable. (E. F. Bachner, Jr. Paper, *Soc. Plastics Industry*, May 9, 1947 Meeting, 4 pp.)

Corrosion Resistant Bearing Alloys

Condensed from
"Archiv für das Eisenhüttenwesen"

In the construction of chemical equipment it is often difficult to select a suitable bearing alloy, since it must have high corrosion resistance, good abrasion resistance and a low coefficient of friction. For some applications, such as organic acids and sulfuric acid, the well known bronzes are satisfactory. In many other cases it is necessary to use different materials with relatively unknown bearing properties.

Tests were made on gray irons with 1.2 to 3.1 carbon, 2.2 to 7.8 silicon, 0 to 12.5 chromium, 13.6 to 27.5 nickel, 0 to 14.9 copper, 0 to 3.3 molybdenum and 0 to 2.8% antimony. With medium hard shafts, the austenitic nickel gray irons have good bearing properties provided the carbides are not too large. The bearing properties can be improved by the use of hardened shafts or by small additions of antimony (for example, 0.9%).

DIGEST

The nickel gray irons are very resistant to alkalis up to high temperatures. Their acid resistance is not significantly improved by increasing the chromium content. An increase in the copper content improves mainly the resistance to sulfuric acid. The resistance to hydrochloric acid is improved by the addition of molybdenum and, particularly, of antimony.

Only high chromium steels can be used for the nitric acid industry. The bearing properties of the cast chromium steels with a ferritic-carbidic structure (0.54 to 1.53 carbon, 0.84 to 1.32 silicon, 24.90 to 29.64 chromium and 2.25 to 2.70% molybdenum) are considerably better than those of the austenitic chromium-nickel steel castings. The austenitic-ferritic, chromium-manganese cast steel, however, has better bearing properties.

The final series of tests were made on zinc bronze, aluminum bronze, lead bronze, a lead-antimony alloy and three aluminum alloys. The aluminum bronze has good chemical resistance. Certain of the aluminum alloy bearing materials have good bearing properties. They have adequate corrosion resistance, however, only to organic acids. (C. H. Meyer. *Arch. Eisenhüttenwesen,* Vol. 13, 1939/40, pp. 437-444.)

Improving Ductility of Aluminum Sand Casting Alloys

Condensed from a Paper of the American Foundrymen's Association

Improvement in elongation values of some heat treated aluminum alloys castings can be obtained by aging the castings one day at room temperature after quenching and before artificial aging. This treatment pertains principally to those aluminum alloys in which Mg_2Si is the hardening compound precipitated upon aging. Two such alloys are 7 silicon—0.3% magnesium, and 1 copper—5 silicon—0.5% magnesium. Those alloys which contain as much as 4% copper, and are hardened by the precipitation of $CuAl_2$, are not affected, and cannot be improved by time delays at room temperature.

If aging at elevated temperatures is conducted immediately after quenching, high strengths and hardness are obtained at the expense of elongation.

Often the time at room temperature between quenching and artificial aging is not very carefully controlled. Furnace availability and labor-shift changes often influence this time interval. In some instances, quenched castings are immediately transferred to an aging furnace; in others they

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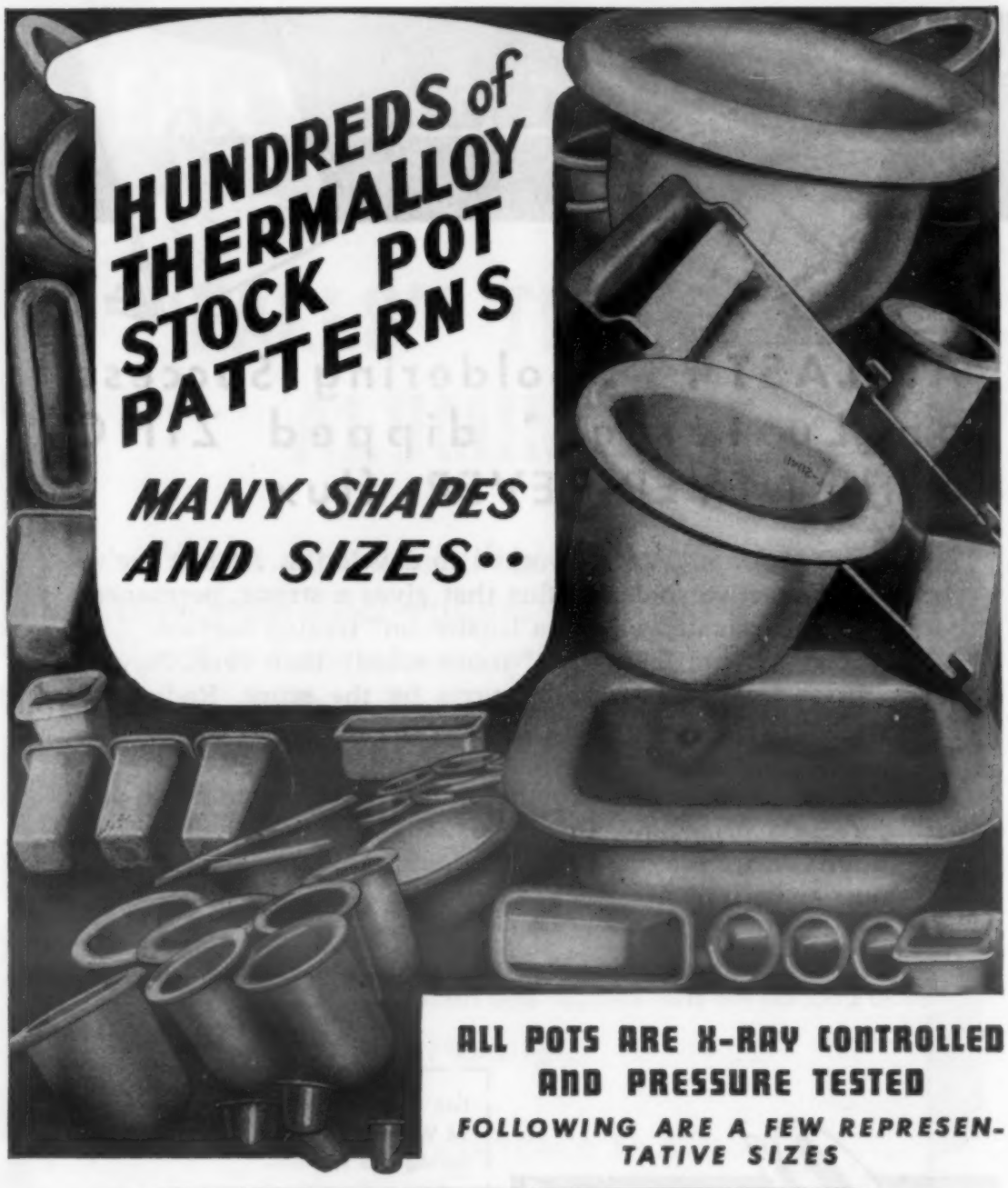

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6¾ x 7	12 x 11	14 x 24	18 x 20	24¼ x 24
8 x 8	12 x 12	14 x 30	18 x 24	24¼ x 24¾
8 x 10	12 x 14	14 x 32	18 x 30	25½ x 24
8 x 12	12 x 16	14 x 36	19 x 15	27¾ x 38⅛
8 x 14	12 x 18	16 x 14	19 x 16	28 x 24
8 x 18	12 x 20	16 x 16	19 x 34	29 x 20
8 x 31	12 x 24	16 x 18	20 x 15	29 x 23¾
8¾ x 10	12 x 30	16 x 20	20 x 17	30¾ x15⁷/₁₆
8¾ x 10⅜	12 x 64	16 x 24	20 x 20	33¼ x 21
9¾ x 17⅝	12 x 32	16 x 27	20 x 30	36 x 30
10 x 10	12¾ x 14	16 x 30	20 x 34	36 x 36
10 x 12	14 x 12	16½ x 17	20 x 80	38¾ x 40
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may be held for a night shift; occasiona week-ends may involve three or more d of time lag. Such variation of the inter between quenching and artificial aging sults in different physical properties with a melt. R. A. Quadt. Paper, *Am. Foundr men's Assoc.*, Apr. 28, 1947 Meeting.)

Surface Hardening Method for Aluminum Alloys

Condensed from "Metallurgia"

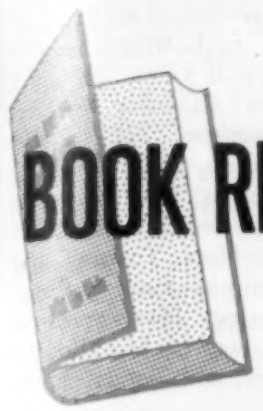
For some time suitable methods of su face hardening aluminum have be sought. It has been found that anodizin siliconizing, and chromium and nick electroplated coatings are not very sati factory.

A method in which the surface is e riched with copper appears to have pro ise. The electrodeposition of copper onto t surface by the Travers process proved mo suitable. The diffusion of the copper w obtained by heating the duraluminu samples at 930 F. Copper oxidized fair rapidly so the loss of copper as oxide w quite appreciable without the use of controlled atmosphere. Oxygen-free nitr gen, however, reduced oxidation to a negl gible degree.

In general, the adhesion was good, eith with or without an intermediate nick plate. Diffusion took place with the forma tion of two clearly defined layers. The out layer was identified as CuAl and the inn as $CuAl_2$. The copper-rich phase appear to be more brittle, while the aluminum rich phase seemed to be reasonably ductil With a sufficiently long diffusion, only t $CuAl_2$ was obtained.

A flash nickel coating over the copp prevented oxidation during diffusion in a but the phase formed on the outer surfac was considerably softer than the phas obtained in the absence of nickel. Th Knoop hardness (50 g. load) of the Cu was about 550 (580 V.P.H.) and of th $CuAl_2$, 420 (390 V.P.H.).

By careful control, it is thus possible t obtain a hard surface layer of reasonabl good uniformity. In practice it would ap pear advisable either to remove the copper rich phase mechanically or to select platin and diffusion conditions that would giv a uniform, aluminum-rich phase at th surface. It is considered that the corrosion resistance would be good if the coating wer sound and homogeneous, but that the co rosion resistance would be considerably re duced in the event of an unsound coatin or rupture during service. (K. G. Robinso & B. W. Mott. *Metallurgia*, Vol. 35, Feb 1947, pp. 201-204.)



BOOK REVIEWS

Laminated Plastics

LOW-PRESSURE LAMINATING OF PLASTICS. *By J. S. Hicks. Published by Reinhold Publishing Corp., New York 18, 1947. Cloth, 6¼ x 9¼ in., 171 pages. Price $4.50.* This is another in the Reinhold Plastics Series of books. The subject, the low-pressure laminating and fabricating of plastics, is very young, dating only from about V-J day. It is one of the most significant advances made recently in the plastics field.

This book is intended to outline the several steps necessary to fabricate a laminate, to point out sources of necessary materials, and to mention some pitfalls to be avoided. The fundamental elements and guiding principles are described so that to the novice the field of plastics will appear neither as a hodge-podge nor as a final well-organized fund of information.

Most of the information presented is a result of war experience. Full operating details and descriptions are given. The text is fully illustrated with 100 pictures showing laminating operations in all the steps. Names and addresses of necessary raw material and equipment suppliers are included, as is also a complete bibliography.

The text is clearly and concisely written. The book will appeal to plastics engineers, glass technologists, and manufacturers of plastic process equipment. There are eight chapters. The authors hold responsible positions with the Owens-Corning Fiberglas Corp. of Toledo, Ohio.

Utilizing the Heat Treating Process

MANUAL FOR HEAT TREATING SERVICES. *Published by Metal Treating Institute, New York, 1946. Looseleaf fabrikoid binder, 8½ x 11 in., 67 pages. Price $4.00.* This manual is designed to help manufacturers get the full advantages of commercial heat-treating services. Its purpose is threefold: (1) "to point out the possibilities of heat treating as a means of increasing the quality and decreasing the cost of metal parts and products"; (2) "to acquaint the nontechnical manufacturer with the basic fundamentals of heat treating"; and (3) "to indicate how heat treating services should be ordered so that the commercial heat treater may know the specific requirements of the manufacturer."

There are 15 sections in which there

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are 12 tables. One section is made up of seven useful tables. Each section is well illustrated with practical views. The titles of the sections follow: Choosing the Steel for the Job; Peacetime "NE" Steels; Machinability; Grinding; Relationship of Heat Treating to Design; Basic Principles of Heat Treating; Types of Heat Treatments; Nonferrous Heat Treating and Brazing; Cold Treating; Steel Surfaces; Inspection and Testing; How to Order Heat Treating; Glossary of Metallurgical Terms; Useful Tables; and Topical Index.

The Engineer as a Civic Person

THE ENGINEER IN SOCIETY. *By John Mills. Published by D. Van Nostrand Co., Inc., New York, 1946. Cloth, 5½ x 8 in., 196 pages. Price $2.50.* This is not a technical book. It is described as "a brilliant and provocative book about engineers and scientists and their relationship to the economics and politics of our world." It is presented in a chatty style.

The author spent 45 yr. of intimate association with creative workers in science—10 yr. in teaching; 10 yr. as a research engineer in telephony, wire and radio; 5 yr. in personnel work for the Bell Telephone Laboratories; and then 20 yr. in assisting colleagues in the publication of the results of their research. Observations and conclusions from these 45 yr. are presented—years that saw the initiation of industrial research and its rapid expansion.

The 18 chapters are grouped under the following broad titles: What Manner of Men; Scientists Gone Executive; Salary Curves; A Course for Action; Exposition for Engineers.

Metallurgy

METALLURGY—THIRD EDITION. *By Carl G. Johnson. Published by American Technical Society, Chicago, Ill., 1946. Cloth, 5¾ x 8½ in., 418 pages. Price $5.00.* This, like the previous editions, is an excellent elementary review, which presents in a simple manner some of the available knowledge concerning the manufacture and behavior of the many metals and alloys in use in our modern civilization. In the new edition information has been added on bearing alloys, aluminum alloys, copper and copper alloys, alloy steels, cast iron, and heat treatments. Practical up-to-date information is included covering the extraction of metals from their ores as well as on the refining and alloying operations.

The equipment used and the method of making microscopic examinations are discussed in simple language. There are groups of quiz questions after each chapter. A comprehensive list of reading references is included, as well as a glossary of commonly used terms.

The titles of the 16 chapters follow: Properties of Metals and Tests to Determine Their Uses; Chemical Metallurgy; Producing Iron and Steel; Physical Metallurgy; The Theory of Alloys; Shaping and Forming Metals; Bearing Metals; Light

Metals and Alloys; Copper and Its Alloys; Steel—Man's Servant; Heat Treatments for Steel; Surface Treatments; Alloy or Special Steels; Classification of Steels; Cast Iron; and Powder Metallurgy.

Machine Elements and Mechanisms

ELEMENTS OF MECHANISM — SIXTH EDITION. *By Peter Schwamb, A. L. Merrill & W. H. James. (Revised by V. L. Doughtie.) Published by John Wiley & Sons, Inc., New York, 1947. Cloth, 6 x 9¼ in., 428 pages. Price $4.00.* This edition has been completely revised by Mr. Doughtie, who is professor of mechanical engineering at the University of Texas. In the revision of this well-established textbook, he has kept two aims in mind: Retention of fundamentals, and the use of current terminology, notation, standards, illustrations, and examples.

This is an authoritative book which gives the fundamental principles of kinematics in the field of mechanical movements. Principal machine elements are selected, and a study presented of their motions when combined in certain ways.

The sixth edition, completely revised to offer recent data on the subject, maintains the sound basic approach of the original authors. Laboratory problems emphasizing practical application of theory are included for the first time. A large number of line drawings are copiously used to illustrate the chapters and the problems.

Other New Books

PROCEEDINGS OF THE AMERICAN ELECTROPLATERS' SOCIETY 33D ANNUAL TECHNICAL SESSIONS. *Published by American Electroplaters' Society, Box 168, Jenkintown, Pa., 1946. Cloth, 6¼ x 9¼ in., 312 pages. Price $6.50.* Comprises the papers presented at the Society's annual meeting in 1946.

MACHINE-SHOP ESTIMATING. *By W. A. Nordhoff. Published by McGraw-Hill Book Co., Inc., New York, 1947. Cloth, 5½ x 8½ in., 486 pages. Price $6.00.* With the help of these data an untrained person can do an efficient job of estimating in a relatively short time with very little supervision. There are 24 chapters; over 90 problems are interspersed in most of the chapters.

THE NEW PLASTICS—THIRD PRINTING. *By H. R. Simonds, M. H. Bigelow, assisted by J. V. Sherman. Published by D. Van Nostrand Co., Inc., New York, 1945. Cloth, 5¾ x 8¾ in., 320 pages. Price $4.50.* Assembles information on all the important plastics materials developed since 1940.

PRODUCTION PROCESSES—THEIR INFLUENCE ON DESIGN. *By Roger W. Bolz. Published by Penton Publishing Co., Cleveland 13, Ohio, 1946. Heavy paper, 8½ x 11 in., 100 pages. Price $1.00.* Contains a series of 15 articles published in *Machine Design* from July 1945 through September 1946, covering broaching, die forging, stamping, flame cutting, cold heading, shot peening.

LAND OF PLENTY. *By Walter Dorwin Teague. Published by Harcourt, Brace & Co., New York, 1947. Cloth, 5½ x 8¼ in., 319 pages. Price $3.00.* The author, a famous industrial designer, discusses new alloys and synthetic materials, new sources of power, new houses and communities, new planes and ships and automobiles.

STRESS CORROSION CRACKING OF MILD STEEL. *By J. T. Waber & H. J. McDonald. Published by Corrosion Publishing Co., Pittsburgh 12, Pa. Heavy paper, 5¾ x 8¾ in., 94 pages. Price $2.00.* In this publication a theory of stress corrosion is presented. The importance of nitrogen as a factor is also discussed. There are eight chapters and a large number of illustrations and tables.

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Engineering Shop Notes

A Quick Acting Drill Jig

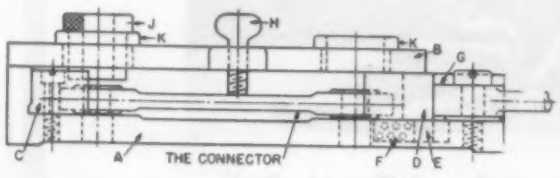
by Robert Mawson

Some of the important features to be worked for when designing a drill jig are accuracy, simplicity and quick acting. Here is a jig for a connector that has all three of these features.

The connector is made from a steel casting in which two holes are drilled and which are later tapped with 1-in. I4 threads. Bosses on both surfaces of the holes must also be machined to a width of 1 in.

The drill jig designed to perform these operations is made with a base "A" to which is attached, by means of screws, jig plate "B". In the plate are located drill guide bushings "K".

At one end of the jig base is a fixed locating V-block "C". At the opposite end of the jig is another locating V-block "D". However, this member is not fixed but is free to slide longitudinally. This V-block is made with a projection "E", which sets into a machined recess



Front view of drill jig with a connector in place.

in the jig base. In front of this projection is a tension spring "F", which bears against the projection at one end and against the end of the machined recess at the opposite end. A cam "G", operated by a handle, is located so that when the cam is rotated, pressure can be exerted on the outer surface of the movable V-block.

To use the drill jig the cam handle is raised to remove the pressure from the movable V-block and as this is removed the spring "F" acting on the projection "E" forces back the movable locating V-block.

The operator now slides one end of the connector into the fixed V-block and the opposite end of the connector into the movable locating V-block. The operator pulls down the cam handle and as the cam is rotated the V-block pushes the connector back into position into the fixed block.

The thumb screw "H" is then tightened, which holds the piece in position. A hole can then be drilled to suit the 1-in. I4 threads, the drill being guided through the bushing "J". This bushing is then removed and placed in the fixed bushing "K" and the drilling operation repeated.

The movable bushing is then removed from the jig and the two drilled holes are tapped. The upper surfaces of the bosses are next faced, the tool being guided through the bushings "K", using a stop collar on the facing tool to determine the correct depth of machining. Pressure on the thumb screw is then released, the cam operated by the handle and the piece removed from the drill jig.

The connector is now turned over and located and placed in the jig again in a similar manner as described. The two bosses can now be faced to the proper width using the same facing tool, after the stop collars have been reset to the new position, and the machining operations are completed. The piece is then removed from the jig in the manner already described.

Spray Quench for Tubular Assemblies

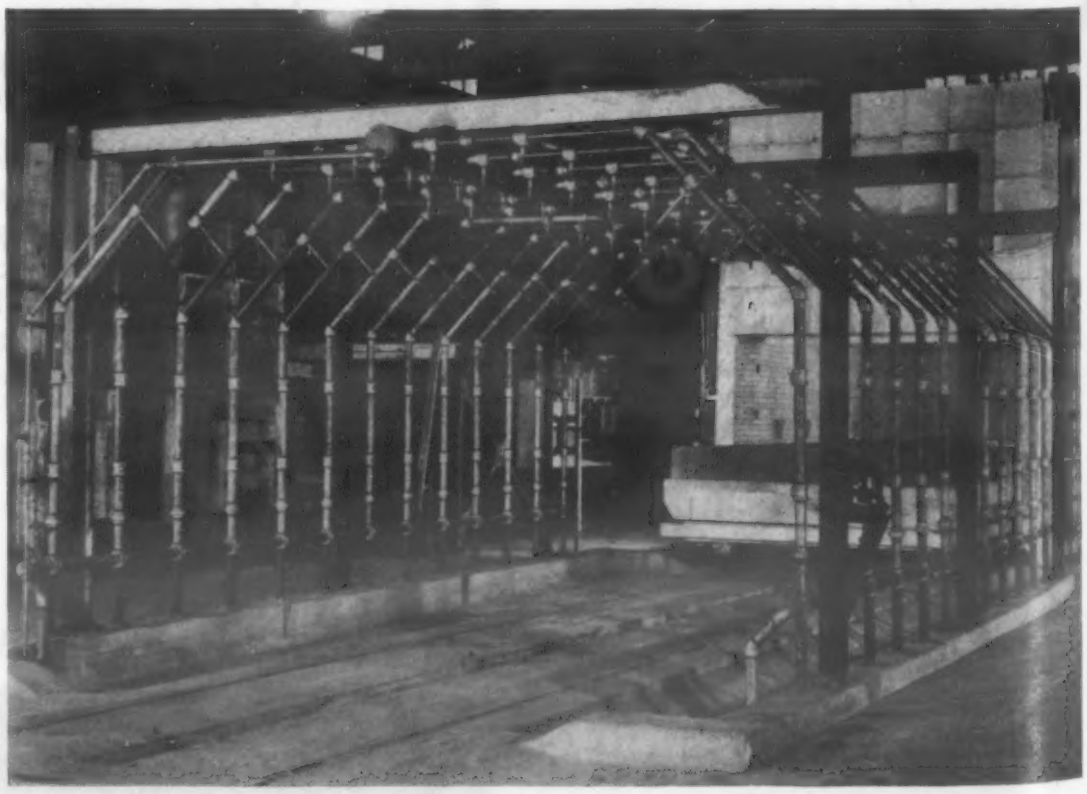
by Walter H. Holcroft,
Holcroft & Co.

In heat treating applications, spray quenching should not be overlooked, for where it can be used it will often reduce considerably the time required for the quenching operation.

A recently-installed Holcroft car hearth type furnace for stabilizing welded chromium-nickel steel assemblies features a water spray quenching arrangement that cools the entire load in 3 min. This installation is designed for handling bulky and odd-shaped tubular assemblies, and has a capacity of 10 tons.

The heat treatment consists of bringing the load to 1950 F, holding it at that temperature until the carbides go back into solution, and cooling rapidly through the carbide precipitation range (1600 to 800 F) to hold the carbides in solution. The furnace heats the work to 1950 F in 4 hr., and maintains that temperature within plus or minus 10 F, throughout the load.

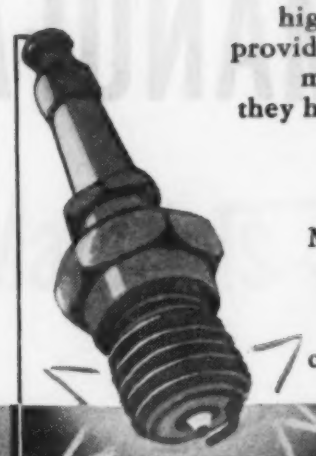
Using more than 100 high-volume nozzles, the spray system supplies the unusually heavy flow of water required to cool the 10-ton load and car hearth in the specified time of 3 min. To avoid the use of excessively large water mains, the system is fed from a large overhead storage tank, which is refilled between quenches.



A view of the spray quench arrangement for handling large and bulky parts.

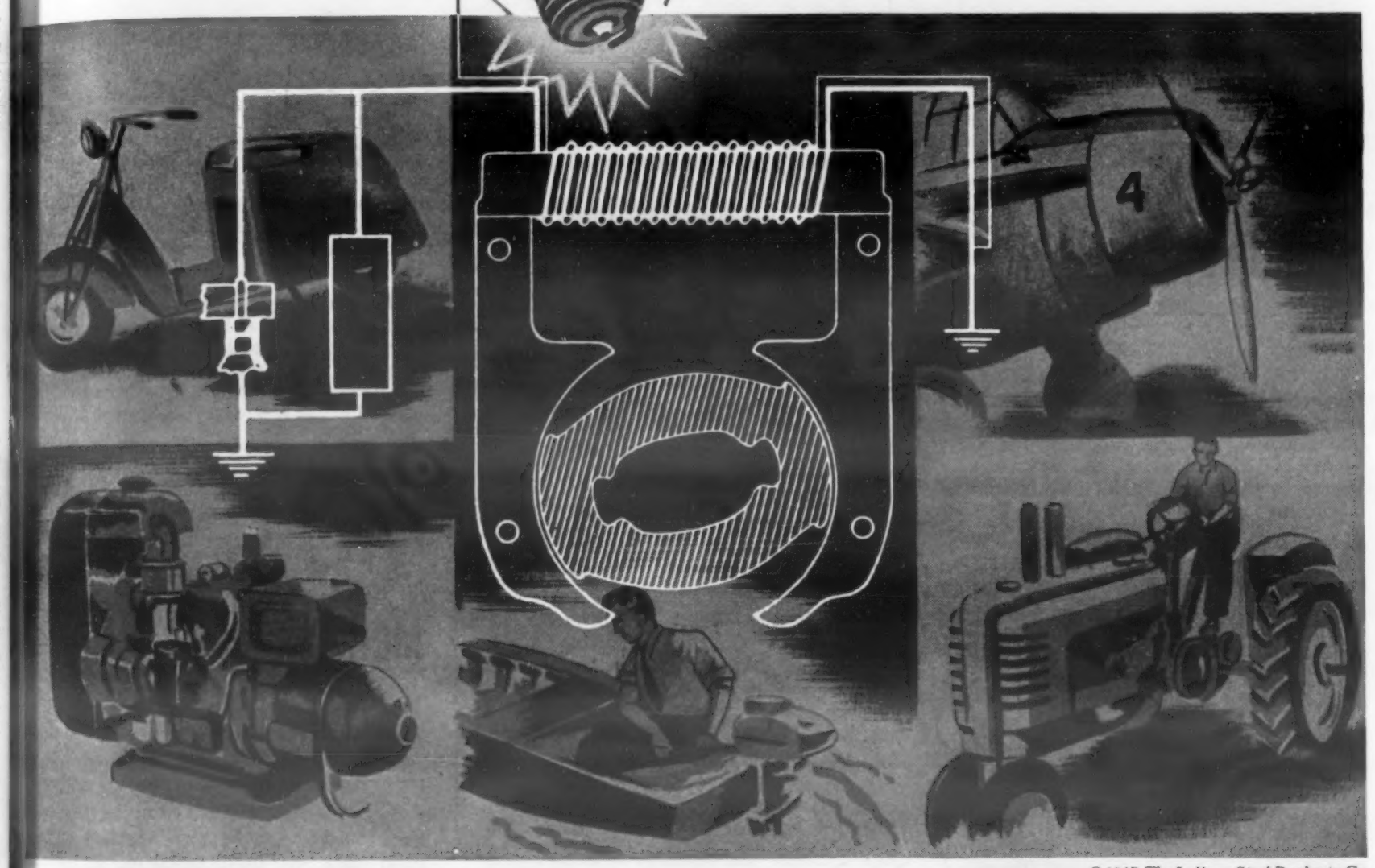
PERMANENT MAGNETS MAY DO IT BETTER

Magnets are hot stuff



In aircraft, motorcycles, speed boats, tractors, motor buses—internal combustion engines which must maintain highest efficiency depend upon the magneto. Unfailingly, it provides a HOT SPARK. After prolonged periods of idleness, magneto-equipped engines kick over instantly, even after they have been subjected to adverse temperatures or excessive moisture. The "Packaged Energy" of the permanent magnet within the magneto is the secret of this exceptional performance.

Magnetos made several decades ago are still functioning efficiently. Today, however, the development of Alnico magnetic materials has made possible the production of modern magnetos which, though amazingly more compact in design, are even more efficient in performance.



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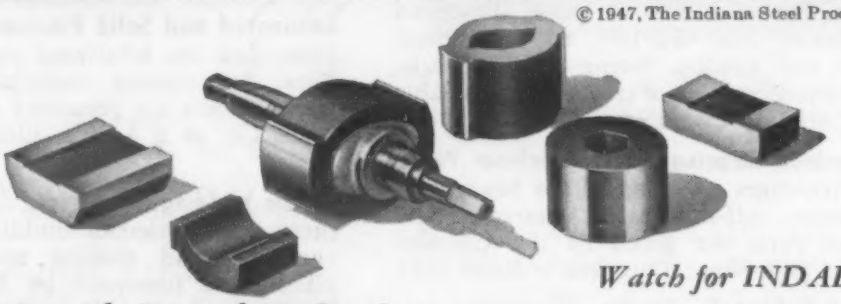
Modern Specialty Designing

Results during wartime proved that the engineers of the parts manufacturer are best equipped to design component parts. The Indiana Steel Products Company has always welcomed such assignments. We take pride in providing the outstanding design and engineering service in the permanent magnet industry. Our engineers will welcome the opportunity to assist you in your magnet problems. They can consult with you, too, about the assembly of rotors or flywheels which may greatly reduce your production costs.



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Growth Comes from Service

At Valparaiso, Indiana, we have the largest plant in the world devoted exclusively to the production of permanent magnets. Special magnetic materials and assemblies are produced at our new Sawmill River plant located at Chauncey, Westchester County, N. Y.

From these plants come permanent magnets of every size, type, design, and material. Materials include Alnico I, II, III, IV, V, VI, and XII, Chrome, Tungsten, and Cobalt, the new Cunico, Cunife I and Cunife II, Vectolite, and Silmanal, as well as Sintered Magnets and our new Hyflux magnetic recording tape.

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Materials

Magnetic Materials. The comparative properties of the wide range of magnetic steels and alloys now being produced for every branch of the electrical industry are included in this 32-page brochure offered by Allegheny-Ludlum Steel Corp. (1)

Ceramics. A detailed table on the mechanical and electrical properties of AlSiMag ceramics, their tolerances, and graphs on their linear thermal expansion and dielectric strength are all included in a complete wall chart, No. 346, offered by American Lava Corp. (2)

Nickel Steel Tubing. The mechanical and working characteristics, heat treating behavior, and weldability of a newly developed 9% nickel steel tubing produced by Babcock & Wilcox Tube Co. are described and illustrated in a 10-page bulletin, No. TR-508. (3)

Carbide Tools. A new 16-page, illustrated supplement, No. GT-199, to its general carbide tool catalog, listing new products, specifications and price changes, is available from Carboloy Co., Inc. (4)

Oil Cushion Bearings and Machine Parts. The advantages of using Oilite heavy-duty oil-cushion self-lubricating bearings and machine parts are given by the Chrysler Corp. in an 8-page, illustrated bulletin. (5)

Laminated Phenolic Plastic. Complete data on Dilecto, a laminated phenolic plastic, including its mechanical and electrical properties, specifications, etc., are presented by Continental-Diamond Fibre Co. in a 42-page, illustrated catalog, No. DO46. (6)

Plastics. The facilities of the Continental Plastics Corp. for producing custom-molded plastic products and parts are discussed in a 4-page, illustrated bulletin, 1b-15. (7)

Molded Plastics. The engineering facilities, machinery, personnel and space of the Harry Davies Molding Co. for producing custom molded plastics are pictorially displayed in a 4-page bulletin. (8)

Extruded Plastics. An attractive, 34-page, illustrated book offered by Detroit Macoid Corp. discusses in detail the manufacture, application and selection of all extruded plastics. (9)

Silicones. Two interesting articles on how silicones are made, what they can do, and test results of silicone as electrical insulation are incorporated into a 12-page, illustrated bulletin offered by Dow-Corning Corp. (10)

Plastics and Metals. A wide variety of ornamental plastics, stamped, rolled, and formed metals, rubber-like plastics, plastic and metal combinations, etc. produced by Electric Auto-Lite Co. are pictorially displayed in a colorful 16-page bulletin. (11)

Plastics. A wide variety of products made with Velon plastics are profusely illustrated and described in an attractive, 12-page bulletin issued by Firestone Industrial Products Co. (12)

Molded Plastics. The complete facilities of the Grigoleit Co. for producing molded plastic products in thermosetting and thermoplastic materials for a wide range of applications are discussed in a 4-page booklet. (13)

Stainless-Clad Steels. Numerous tables showing the resistance of stainless-clad steels to corrosion are included in this 16-page, illustrated bulletin, No. 338, just released by the Lukens Steel Co. (14)

Laminated and Solid Precious Metals. Complete data on fabricated parts and assemblies, bar contact material and precious metal solders are presented by D. E. Makepeace Co. in a 4-page, illustrated bulletin. (15)

Plastic Molding. Complete data on the compression and injection molding, design engineering, mold making and finishing of plastics are presented by Modern Plastics Corp. in a 6-page, illustrated folder. (16)

Perforated Metals. The perforation of steel, brass, copper, Monel, zinc, lead, etc. as specified for all kinds of screens is profusely illustrated and described in an 8-page, pocket-size folder, offered by Charles Mundt & Sons. (17)

Plastics. Complete data on various Plaskon materials, including plastic molding compounds, resin glues and resins, are presented by the Plaskon Div., Libbey-Owens-Ford Glass Co. in a 4-page, illustrated bulletin. (18)

Powdered Metal Parts. Typical applications of various powdered metal parts produced by the Powdered Metal Products Corp. are presented in a 4-page, illustrated bulletin. (19)

Rigidized Metals. This attractive, 12-page bulletin published by Rigid-Tex Corp. describes and illustrates the Rigidizing process for ferrous and nonferrous strip and sheet metal. Typical applications are included. (20)

Bushing Stock. A complete line of centrifugally cast tubular bushing stock and chill cast solid bar stock in a wide range of diameters and standard 13-in. lengths, semi-finished, is presented by Shenango-Penn Mold Co. in a 4-page, illustrated bulletin No. 145. (21)

Carbon-Graphite. The characteristics and typical applications of Graphiter, a carbon-graphite material, are discussed in an attractive, 40-page, illustrated catalog, issued by the U. S. Graphite Co. (22)

Methods and Equipment

Hard Surfacing by Fusion Welding. Complete data on hard surfacing by fusion welding are presented by American Brake Shoe Co. in a 100-page book written by H. S. Avery. This book is fully illustrated and contains numerous photomicrographs, tables and diagrams. (23)

Rust Remover. Technical Service Data Sheet No. 3-1-1-2, four pages, illustrates how Deoxidine, a phosphoric acid metal cleaner and rust remover, removes grease, oil or rust, and cleans and conditions metals correctly for painting. American Chemical Paint Co. (24)

Welding Brass and Tin Bronzes. Recommended electrodes, polarity and current, amperage and voltage, preparation and detailed procedures of welding brass and tin bronzes are all contained in a group of procedure sheets, No. W7-10, issued by Ampco Metal, Inc. (25)

Metal Coating. Tuf-On P-70 Pri-Met, a new chemical prime coat for maximum adhesion on brass, steel, tin, cadmium, lead, zinc, etc., is discussed in a 4-page bulletin, No. 101, offered by Brooklyn Varnish Mfg. Co., Inc. Specifications are included. (26)

Spacers. This 20-page, illustrated bulletin discusses the Man-Au-Trol spacer, a unit applied to radial or upright drilling ma-

New Materials and Equipment

Boring Head Designed for Repetitive Boring Operations

Designed for repetitive boring operations, this new boring tool manufactured by the *Kaukauna Machine Corp.*, Kaukauna, Wis., is said to be efficient and economical on any run of boring work of more than three pieces. Without changing cutter bits, it is possible to rough, semi-finish and finish bore. To do this, the boring head, which is mounted on an eccentric arbor, is indexed for individual cuts.

The tool is used for stub bar boring only and is especially adapted for rapid standard or heavy duty precision work. Either carbide cutting tools or high-speed steel bits may be used.

These boring tools consist of the following parts: alloy steel, heat treated integral eccentric arbor and shank, a detachable boring head, drive key and knurled lock nut. The end of the eccentric arbor is threaded to receive the lock nut and it, in turn, is tightened with a spanner wrench to secure the boring head to the arbor body. The drive key projects from the body of the arbor. This key snugly fits into each of the three slots in the boring head and serves as the indexing stops for the cutters.

Using ordinary ⅜ by ⅜-in. tool bits and different diameter heads, it is possible to bore any size holes from 4 to 8⅛ in. in dia. Tool bits can be adjusted in each size head to give a range of approximately ⅜-in. variation of dia.

Indexing cutter head rapidly positions cutters for rough, semi-finish and finish boring.

A heavy duty series of heads and arbors are also available. These heads are designed for ½ by ½-in. tool bits and have a range of bore sizes from 4⅞ to 11⅜ in. dia. In this head tool bits can be adjusted to give a variation of approximately ½ in. in dia.

A lighter Kwik-Size boring tool, using ⅜ by ⅜-in. tool bits has a boring range from 2½ to 5 in. dia.

A New Cleaning Compound for Aluminum

A new metal cleaning compound especially designed for cleaning aluminum, designated as Optimus No. 101A, has been announced by *Optimus Detergents Co.*, 100 Water St., Matawan, N. J. It is a blend of medium duty alkaline cleaner, including special water softening materials and inhibitors to prevent attack on the metal. It is particularly effective for cleaning dirt, grease and oil.

It can also be used as a soak cleaner for ferrous metals other than aluminum, such as die castings, brass, bronze, pewter, etc. In this application, the work can be made the cathode and cleaned electrically. With aluminum, the electro-cleaning application does not apply.

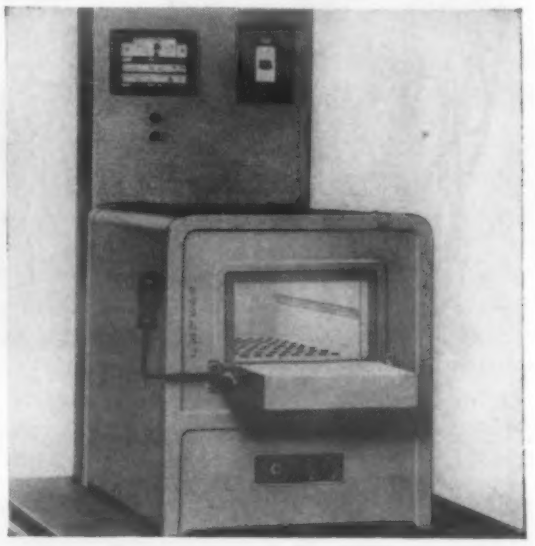
The cleaner includes a synthetic wetting agent and is suitable for hot tank applications. A mild, non-etching type of cleaner, it can be used in small concentrations, with temperature ranging between 140 and 180 F.

A similar material, Optimus No. 101, is applicable for machine washing operations, where the presence of foaming is undesirable.

Electric Box Furnaces Use Recirculating Air Draw Principle

Two new forced circulation furnaces, one for temperatures to 900 F, and the other for operation to 1200 F, have been developed by *Cooley Electric Manufacturing Corp.*, Indianapolis, Ind.

They may be used for tempering or drawing of both carbon and high-speed steels, nonferrous heat treating, etc. They are suitable for tool and die tempering, particularly when made of high-speed steel, since furnace recovery time is rapid and the double temper of high-speed steel is easily obtained. The two furnaces are also suited



The recirculating air draw type electric box furnaces provide rapid, uniform heating for tempering and other operations at temperatures below 1200 F.

to production of small parts, and for laboratory testing of paints and plastics.

A temperature uniformity of plus 5 minus 0 deg. is claimed for these furnaces. Temperature control is effected by means of a new Cooley power modifier, built into both furnaces, and operating with an indicating pyrometer. The modifier corrects temperature lag behind the pyrometer reading, characteristic in electric furnaces and substantial when operating below 1200 F. Overshooting of the pyrometer is eliminated.

The furnace chambers are completely metal lined, using mild steel in the 900 F model, and stainless steel in the 1200 F model. The chamber size is 10 in. wide, 6 in. high and 14 in. deep. Either furnace will accommodate 50 lb. of parts. For light work, an intermediate plate or shelf can be inserted on the horizontal rails at the chamber sides to double the hearth area.

Mash Seam Welder Has Three Dual Welding Heads

A new, mash seam welder with three dual welding heads has been developed by the *Federal Machine & Welder Co.*, Warren, Ohio. The first unit delivered is being used for making refrigerator food compartment liners.

The machine is provided with three 300-kva. water-cooled welding transformers wound for 440-v., 60-cycle, single-phase a.c. power supply, with individual 16-step heat regulators. One welding transformer is mounted in each of the three dual welding heads. The welding wheel spindles are internally water cooled.

The main frame of the machine has special provisions for the traveling fixture carriage and the three traveling duplex seam welding heads. The equipment has its own hydraulic system complete with hydraulic pumping unit and oil cooling reservoir for supplying hydraulic fluid under pressure to the welding head traveling cylinders and fixture carriage actuating cylinder. Each of the six welding heads is provided with its individual air cylinder for applying weld pressure.

The welding heads are angularly mounted to accommodate the welding of the liners, which occurs at a 45-deg. angle. The welding heads are manually adjustable, both vertically and laterally, to accommodate welding of the various size liners. Changes in weld travel length of the welding heads are accomplished by changing limit switch settings.

The mash seam type of weld is said to be superior to the standard overlapping type seam weld as it requires no finishing or dressing, and the enamel may be applied directly.

The new mash seam welder ready to weld the seams on a refrigerator food compartment liner.

Three New Rack Coating Materials

A newly developed material designed for the insulation and protection of plating racks and metal parts exposed to the corrosive conditions which are normally encountered in the cleaning and electrodeposition of metals, has been announced by *U. S. Stoneware,* Akron 9, Ohio. The coating, called Coating 266, is resistant to all plating solutions, including hot alkaline cleaners. Usually two dips are sufficient to give a satisfactory coating thickness. It requires 20 to 30 min. drying time per coat. The coating will withstand 90-deg. bends without cracking and is non-conducting, both anodic and cathodic.

A complete line of rack enamels and stop-off lacquers has been developed by the *Maas & Waldstein Co.,* Newark, N. J. These rack enamels and stop-off lacquers have good adhesion and resistance in the acid and alkaline solutions employed in electroplating processes. They are said to be easy and economical to use and provide effective insulation.

A new vinyl type coating has recently been introduced by *Heil Process Equipment Corp.,* Cleveland, for tanks and rack fixtures used in the plating and chemical industries. The new coating, designated as Heilex 445, has resistance to chemicals and is said to have a tough surface and high bonding characteristics. Acids such as sulfuric, hydrofluoric, hydrochloric as well as nitric and chromic oxidizing acids have no deteriorating effect.

Physically, this plastic is rubbery and tough. If damaged by sharp objects it can be repaired on job site with a patching material. Another unique property is its negligible effect of temperatures up to boiling.

The coating is being used on racks, stanchions, fixtures, tanks in copper, nickel and chrome sequence. It protects the plating solution from contamination and the rack from corrosion.

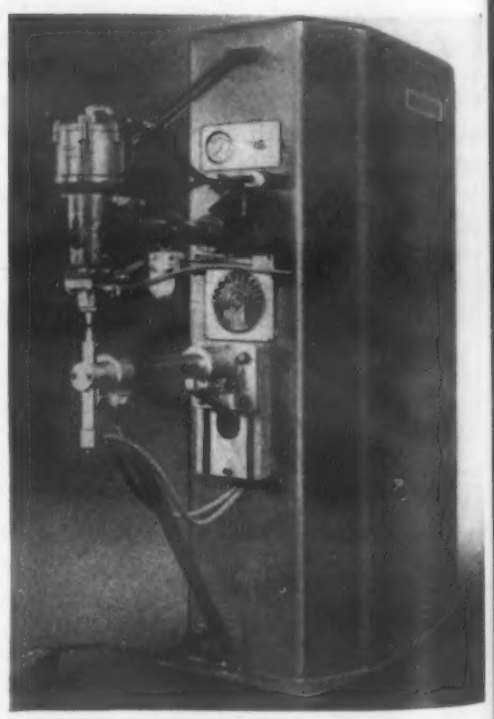
Pedestal Type Spot Welders Adaptable to Job Welding

A new line of 30-, 50- and 75-kva. pedestal type spot welding machines has been introduced by *Progressive Welder Co.*, 3050 E. Outer Drive, Detroit.

Removable sheet metal panels and a full length door on the left side makes accessible all units contained in the machine, including transformer, heat controls, water piping. The right side of the machine column is clear so that it can be used for side mounting of electronic or other welding controls.

From a performance standpoint, the machines are designed to provide both adaptability for job welding runs and high output rates. To facilitate miscellaneous spot welding, knees are quick-adjustable, maximum stroke is 2½ in., and different types of interchangeable electrode holders are available.

Correct pressure regulation is provided by a pressure gage at the front in the head of the machine. Alongside this gage is a knob to regulate the pressure. Welding arms are of large diameter. For deep throat machine support, arms bracing the welding arms are recommended to obtain maximum benefit from the rigid frame.



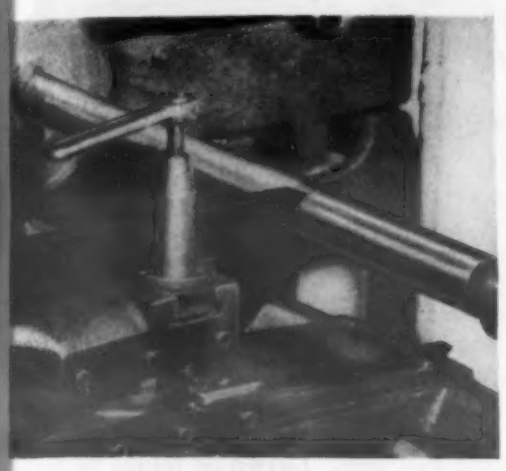
One of the new pedestal spot welders with low inertia head.

Jobs normally requiring swiveling arm construction to clear the work can be handled on these machines as the result of the large throat opening, up to 12½ in., provided.

Rubber-Bonded Abrasives Now Produced in Stick Form

Rubber-bonded abrasives in stick form are now available from *Sandusky Abrasive Wheel Co.*, 698 W. Ransom St., Kalamazoo, Mich. They come in a wide variety of sizes and shapes, and are useful for light grinding, cleaning, deburring, rust removal, sharpening, honing, polishing, etc.

The sticks can be cut and shaped for different finishing contours, grooves and beads. They can be cut with a jack-knife, file, grinding wheel, hacksaw or bandsaw. This makes it possible for tool and die men, patternmakers, machinists, mechanics and others to cut special shapes to fit the deburring, finishing, or polishing operation being performed.



Here shown is an abrasive stick in a lathe tool post finishing a round shaft.

If desired, abrasive stick can be fastened in the tool post of a lathe for finishing operations on journals, rolls, shafts, spindles, etc. For finishing operations and polishing threads, grooves, corners, curves, contours and holes, the triangular shaped and round shaped sticks are best suited.

The abrasive sticks are available in 3-, 6- and 8-in. lengths. They are made in three grains—fine, medium and coarse—and standard shapes include rectangular, square, triangular and round. The sizes range from ¼-in. dia. round shape to 8 by 1 by ½ in. in the rectangular sticks. Blocks are also available, 4 by 4 by ¾ in. for large area finishing operation.

Sealing and Insulating Compound is Non-Flammable

A non-burning plastic sealing and insulating compound for such applications as sealing cable ends and connections and terminal boxes has been announced by *National Engineering Products, Inc.*, Commerce & Savings Bldg., Washington, 4.

The compound, called Tempseal, is resistant to water and is said not to harden and will not crack or craze due to vibration. It is non-toxic and is resistant to heat up to 400 F. The insulation resistance is 1000 megohms; dielectric strength is 1500 v. minimum.

New Welding Electrodes Announced

An improved electrode, originally developed for use by the aircraft industry in welding assemblies to be heat treated after welding, has been announced by the *Air Reduction Sales Co.*, 60 E. 42nd St., New York 17.

Designated Airco No. 190, it is said to have two advantages over its predecessor. One, when welding high strength chromium-moly aircraft steels, the necessity for preheating is minimized. Also, this electrode is less conducive to cracking adjacent to the weld area and between the layers of weld metal when preheating is not employed. It will give tensile strengths up to approximately 150,000 psi., and produce welds more ductile than those previously obtained. Although particularly applicable to the aircraft field, this electrode can also be used on alloy steels where high tensile strengths are required. It can be obtained in 3/32-, 1/8-, 5/32- and 3/16-in. dia.

Another welding rod announced by Airco is the Airco No. 23A, a silicon-copper analysis. It is for copper welding and replaces a phosphorus-deoxidized copper analysis.

A new line of tungsten electrodes for atomic-hydrogen and Inert-Arc welding has been announced by the *Electric Welding Div.* of the *General Electric Co.*, Schenectady, N. Y. Suitable for manual or automatic welding, the new electrodes are said to be free from nonmetallic inclusions, segregation, slivers, cracks, seams and pipes. The electrodes are available in diameters ranging from 0.040 to ½ in., and in lengths from 3 to 24 in. Other lengths up to 60 in. can be furnished on request. Diameters are held to 0.001-in. tolerance.

Continuous Conveyor Oven Has Zone Control of Heat

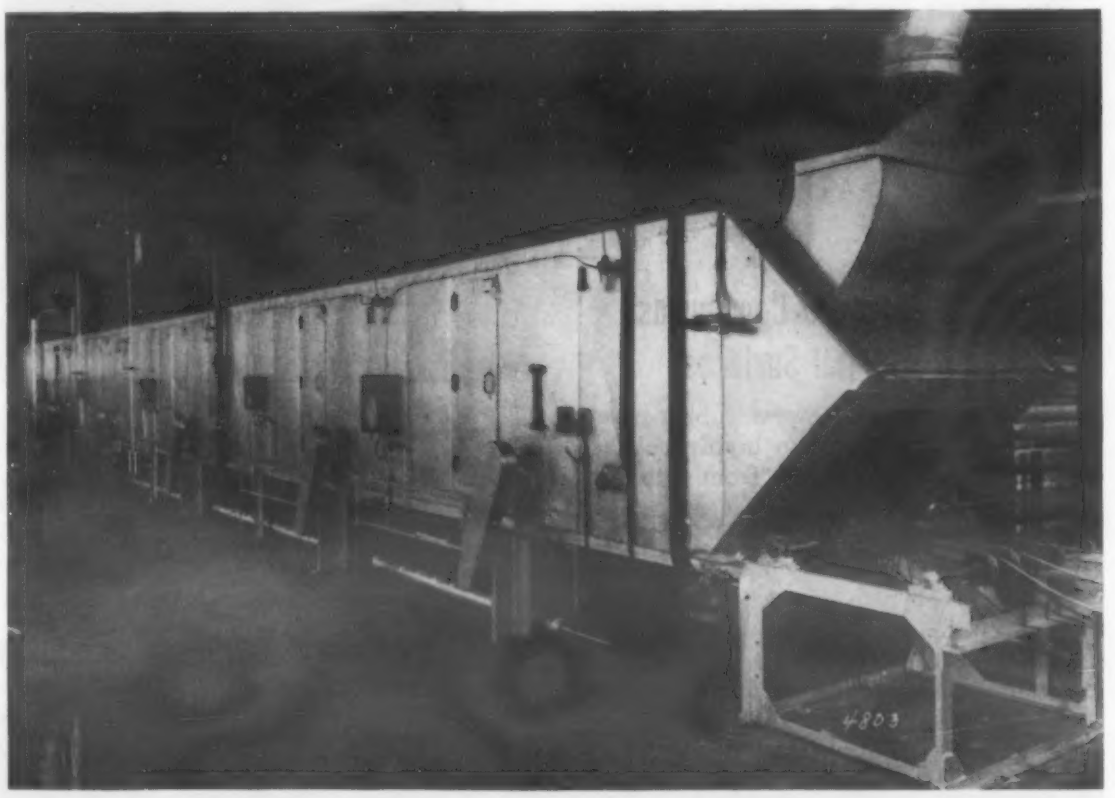
A continuous conveyor coating and lithographing oven has been developed by *Young Brothers Co.*, Detroit 7. The oven incorporates new methods of heating, heat recuperation, zone temperature control, and air recirculation.

The new unit also includes a recuperating zone which recovers the stored heat in the metal sheets and injects this heat back into the baking zone before the work leaves the insulated enclosure, at the discharge end of the oven. The recuperative cooling system, operating in an oven handling a production of 3500 sheets per hr., and at a baking temperature of 400 F, has resulted in the recovery of 30% of the total B.t.u.

The oven is so designed that the burners are within the oven proper and so located that there is no danger of overheating of the sheets, due to direct radiation. Zone control gives the operator control of the heat input throughout the oven. He can vary the temperature to provide the amount of heat most suitable for various phases of the drying process.

The introduction of new coatings to the lithographing industry has dictated that modern oven designs provide for a wide variation in operating temperature. This new oven has each zone equipped with individual heating, recirculating, temperature control, ignition and safety equipment.

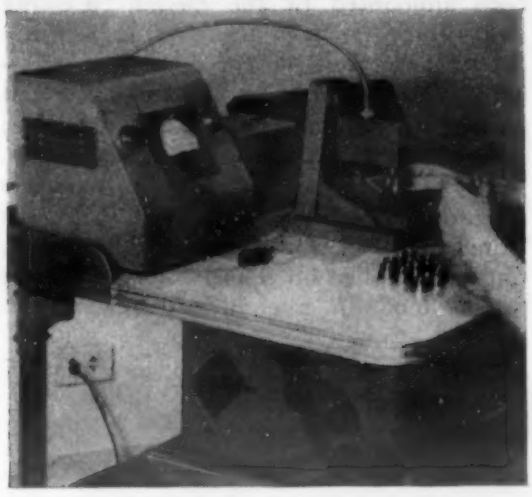
The new oven is manufactured in various lengths and the dimensions selected are determined by the individual production requirements.



Each zone in this oven has individual heating, temperature and recirculating controls.

Inspecting Machine Segregates Parts by Size

An electronic segregator for the automatic sorting of small parts into three classifications, oversize, acceptable and undersize, has been announced by the *DoAll Co.*, Des Plaines, Ill. Accurate to 0.000010 in., the selector will sort parts with tolerances from ±0.0001 to ±0.005 at speeds up to 12,000 parts per hr.



The automatic segregator in action sorting small parts according to size.

The selector consists basically of three units, the gage head, the master control, and the segregator. The head, where the actual measurement is done, is so designed and constructed as to have no frictional moving parts, no coils, no switches and no magnets to need adjustment. The speed of operation is limited only by the rate at which parts can be fed into the selector. Fully automatic and semi-automatic feed mechanisms are available.

Besides having red and green indicating lights, the master control unit has on it a graduated indicating dial gage providing visible readings of the size of each part as it is being sorted. This gage is electronically operated and hermetically sealed against dust and moisture.

The selector can be adapted for measuring internal dimensions, for simultaneous checking of more than one dimension, or for sorting into more than three classifications.

Strippable Plastic Compounds Protect Metal Surfaces

A non-inflammable liquid rubber-plastic which can be sprayed onto highly polished metal parts to protect them from dirt, rust, corrosion, moisture, fingerprints and smudges, is being manufactured by *Rubba*, 1015 E. 173rd St., New York.

Metal parts which are protected by this coating can be handled in the production line, and when the coating is peeled off the metal shows its original lustre. Known as Rubba-Coat, it can also be applied to painted wood sub-assemblies to protect the paint finish as the completed product takes shape. The compound is non-inflammable, waterproof, can be applied by brush, spray-gun, or dip method, and can be removed by peeling.

Spray-Peel is another strippable plastic compound, announced by *Eronel Industries*, 5714 Pico Blvd., Los Angeles. Applied easily by brush or spray, Spray-Peel dries to a rubbery film, has sufficient adhesion to insure complete sealing, and has adequate tensile strength to permit easy stripping.

The new strippable compound is nontoxic and has resistance to moisture, abrasion, salt water, aromatic spirits and oils, alkalies and acids, and all atmospheric temperatures.

Bench-Type Induction Heater Can Be Mechanized

A bench-type induction heating generator combining the power section and work applicator in one unit has been announced by the *Induction Heating Corp.*, 389 Lafayette St., New York 3. The unit, known as Model 43, has a full-load output of 43 B.t.u. per min., which is equivalent to approximately 750 w. at a nominal operating frequency of 450 kilocycles per sec. It is designed for continuous full-load operation in the production line or for short run work.

This generator lends itself to mechanization such as conveyor belts, turntables, rotary spindles for automatic feed or shop-made fixtures for manual feed. It is applicable to hardening, brazing, soft-soldering, annealing and melting operations.

The entire tube complement consists of one standard, heavy-duty, air-cooled oscillator and two standard rectifier tubes. The need for water-cooling of work coils or for any adjustments on the generator unit when changing from one coil to another has been eliminated.

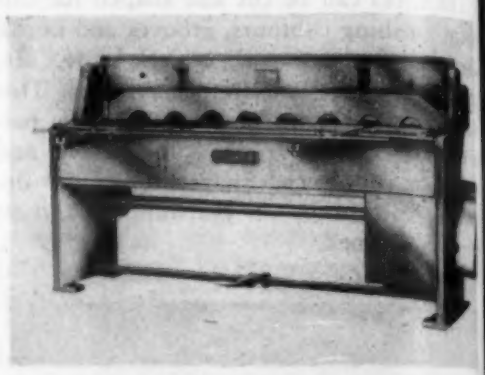
The bench-type induction heating unit in operation, heating a typical small part.

● Internal and external measurements are possible with a micrometer, in production at the *Richards Machine Tool Co.*, 124 S. Isabel St., Glendale 5, Calif. The micrometer is regularly made in three sizes: 0 — 1, 1 — 2, and 2 — 3 in. All wearing surfaces are hardened and ground.

Squaring Shears Allow Close Trim on Drawn Parts

A new 10-gage power squaring shear is now in production at the *Parker Manufacturing Co.*, 2200 Colorado Ave., Santa Monica, Calif. The shears are all-welded design and the bed, ram, hold down and working parts are reinforced.

It is a box type design with a low center



This power squaring shear has a low center of gravity for minimum vibration.

of gravity for minimum vibration. The shears stand 47 in. high and weigh 4250 lb. It has a 5-hp. motor, a speed of 85 strokes per min., cutting length 73 in., blade length 75 in., back gage range 18 in., front gage range 38 in., and floor space 32 by 104 in.

The four-edged blades are of oil hardened tool steel. Drawn or folded parts may be cut to within 1½ in. of their shoulder, allowing a close trim on basins, sinks, cowlings and other similar objects.

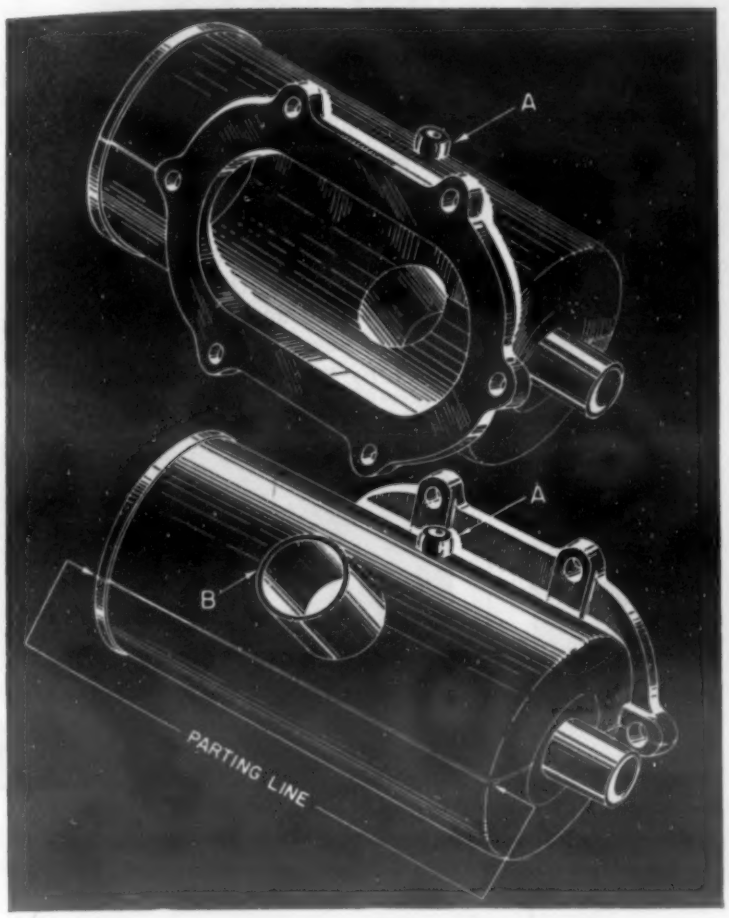
● A complete line of all-steel precision floating holders has been announced by *Barnaby Manufacturing & Tool Co.*, 70 Knowlton St., Bridgeport 8, Conn. These holders, of conventional design, are available in shank diameters of ⅜, ¾, 1 and 1¼ in. The floating holders provide a ready means for aligning drills, reamers and similar tools with the work. The cutting tool is held in the head of the holder, either directly or by means of a bushing, and is clamped by a hardened steel set screw.

New Silver Paste Brazes Carbide Tips

This paste was developed specifically for brazing carbide tips by *Sherman & Co.*, 197 Canal St., New York 13. It consists of a silver brazing alloy finely pulverized and then ground with a special flux.

The flux contained in this paste begins to melt at 480 F and protects both the carbide tip and the steel joint area with a liquid protective film before the heat-generated oxides can form. The viscosity of the flux is low and the molten brazing alloy component eases all of it out of the joint.

To use, the tip is prepared in the usual way and the paste, known as Diffusion Paste No. 50, is painted on the joint surfaces of the carbide tip with a small brush. The tip is held in position and heated.



CORING ELIMINATES MACHINING

In designing die castings, remember that holes and recesses can easily be cored in the casting operation, thus eliminating the need for much machining. Where possible, such openings should be so located that they will be parallel to the die motion, in which case they can be formed by cores which are fixed to, or form integral parts of, the die.

In addition to savings in machining costs, cored holes provide the following advantages:

1. Holes and recesses are accurately sized and precisely located.
2. The quantity of metal required per casting is minimized.
3. Section thickness can be kept more uniform.
4. Overall cost is reduced.

When holes are required at angles *not* parallel to the motion of the die, movable cores are used to permit casting ejection. This may result in increased die cost and reduced casting rates, but the expense is frequently justified. A good case in point is the *zinc alloy* die casting shown above (a drain housing for an automatic washing machine).

Cores are pulled in four directions to form the various holes and recesses in this casting. The small bosses on either side (A) are cored by fixed projections in each half of the die, but the flange opening and screw holes at the top of the casting and the openings at either end require movable cores. In addition, the angle of the hose outlet at the bottom (B) necessitates the use of a slide (movable portion of the die). The added cost of this complicated coring is easily offset by the savings in metal and in machining costs. The coring has also reduced the section thickness of the side walls to approximately 1/16", although the flanges at the top and one end are "beefed up" to provide sections suitable for sanding to obtain gasket surfaces.

ALLOY SELECTION

Good die casting design is of no avail unless the proper alloy is selected. Furthermore, it is imperative that any alloy used in die casting production be carefully formulated with respect to every element involved to insure maximum mechanical properties and dimensional stability. If a zinc alloy is used, your die caster should provide one of those shown in the table below. These alloys are covered by specifications of the American Society For Testing Materials and the Society of Automotive Engineers.

Composition of Zinc Alloys For Die Castings

Composition* % by Weight	ZAMAK†-3 A.S.T.M.-XXIII S.A.E.-903	ZAMAK†-5 A.S.T.M.-XXV S.A.E.-925
Copper	.10 Max.	.75 to 1.25
Aluminum	3.5 to 4.3	3.5 to 4.3
Magnesium	.03 to .08	.03 to .08
Iron, Max.	.100	.100
Lead, Max.	.007	.007
Cadmium, Max.	.005	.005
Tin, Max.	.005	.005
Zinc	Remainder	Remainder

*Composition as provided in A.S.T.M. and S.A.E. Specifications. The Zamak alloys meet these specifications but are held within closer limits as to composition.
† A trade mark (registered in the U. S. Patent Office) identifying the zinc alloys developed by The New Jersey Zinc Company and used in the die casting industry.

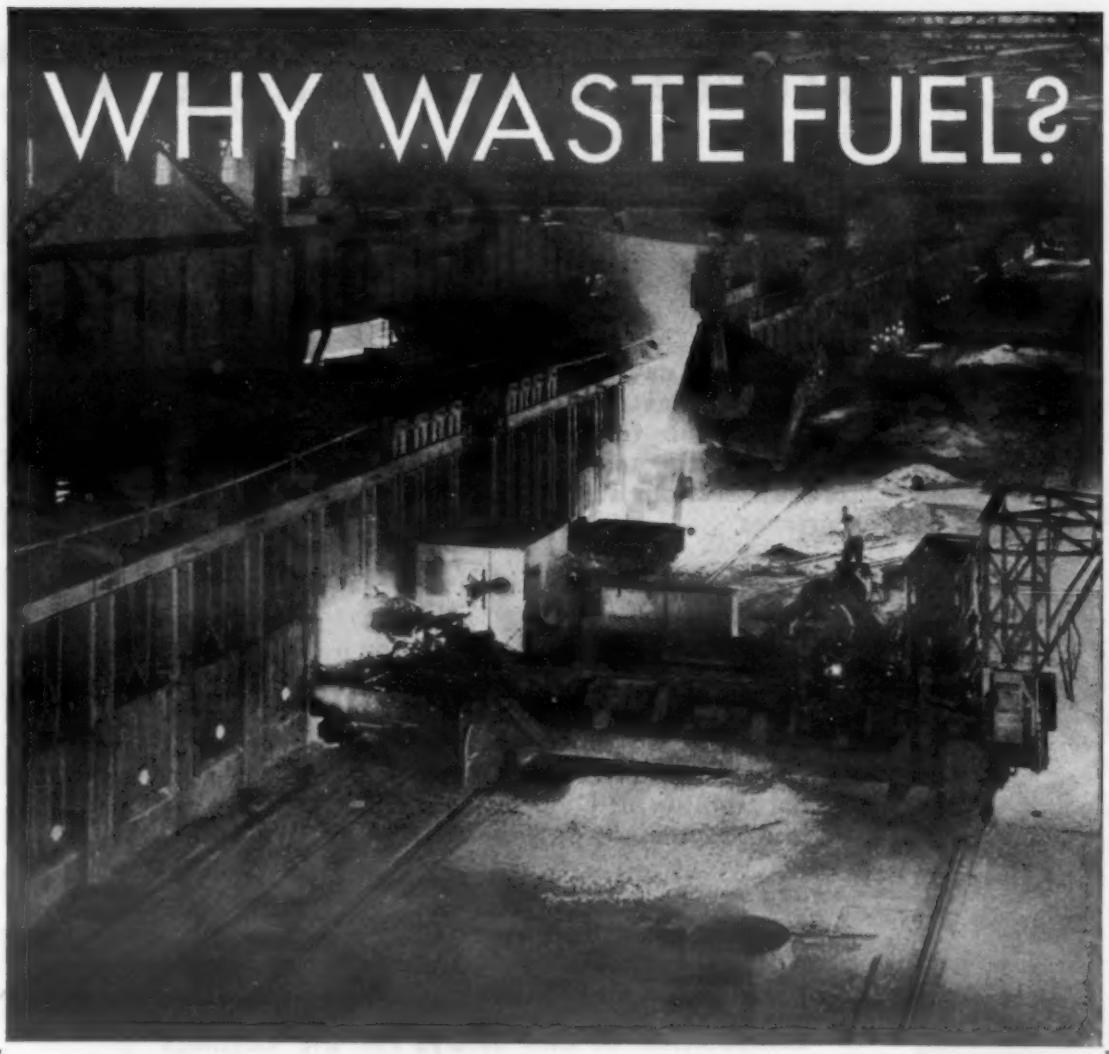
For additional data on die casting design ask us—or your die casting source—for a copy of the booklet "Designing For Die Casting."

Send for your copy ➡

The New Jersey Zinc Company, 160 Front St., New York 7, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC



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Exclusive Manufacturers of
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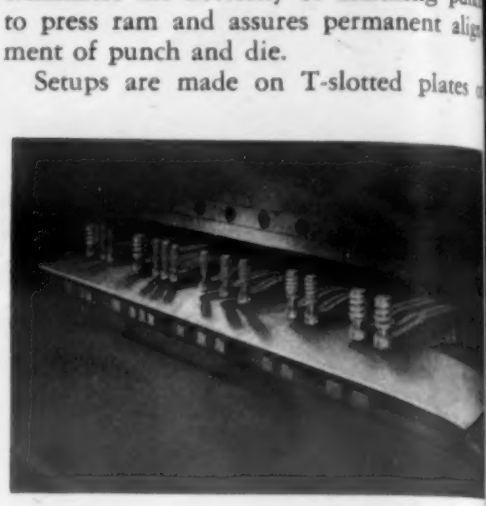
open hearth Insulation

Hole Punching Unit Applicable to Angles and Channels

A heavy-duty type hole punching unit designed to pierce mild steel up to ¼-in. thick has been announced by the *Wales-Strippit Corp.*, 345 Payne Ave., N. Tonawanda, N. Y.

This new unit has a pedestal die that permits the punching of angles and channels as well as flat sheets. The unit consists of a holder that carries the punch, die and stripping mechanism. This patented design eliminates the necessity of attaching punch to press ram and assures permanent alignment of punch and die.

Setups are made on T-slotted plates or templates for stamping presses and press brakes. The press ram only requires one adjustment regardless of how many hole punching patterns are placed in operation because of the uniform shut height of the punching unit.



Staggered patterns setup of Wales heavy-duty "CJ" units set up in press brake.

The units, known as Type CJ, are available in three holder widths with maximum punch dia. of ⅞ in. for use with mild steel up to ¼-in. thick.

Die Casting Machine Features Rapid Closing and Opening of Dies

A die casting machine for die casting zinc, tin and lead with a die opening and closing speed of 750 in. per min. is being manufactured by *Wickes Brothers*, Saginaw, Mich.

The distance between the platen and bolster plates is adjustable from 9 to 23 in. by means of a single lever die adjustment mechanism which can be either hand or power operated. The casting knockout is automatic and hydraulically operated or can be manually operated if desired.

The opening of the dies can be adjusted from 6 to 16 in. by positioning a cam in the trip mechanism. Timing of the momentary slow down can also be set by a cam. Injection pressures are possible for 1500 lb. per sq. in. to 6000 lb. per sq. in.

Dual melting pots are installed in the machine. One pot is the preheat, the other is the injection pot. The heat is supplied by infra red burners.

The injection capacity of the unit is 100 cu. in. Floor space required is 21½ by 6½ ft.

Instrument Purifies Gases Automatically

A new automatic device which removes oxygen impurities and eliminates moisture from gases has been introduced by *Baker & Co., Inc.*, Newark 5, N. J. Called the Deoxo purifier-dryer, the instrument is installed at any convenient point on the low pressure line. It purifies such gases as hydrogen so that less than one part in a million of oxygen impurities remains, and then dries the gas to dew points of better than —50 F. It may also be used with such gases as nitrogen, argon, neon and saturated hydrocarbons.

Its capacity depends upon the moisture content as well as impurity of the incoming gas, which varies with each installation. Using bottle hydrogen of 99.7% purity, at a maximum flow of 50 c.f.h., pure gas, with dew points better than —50 F for over 24 hr. of continuous operation, is attained. This is the equivalent of almost nine bottles of hydrogen.

The instrument is suitable for atmosphere furnace application, as well as for use in such fields as powder metallurgy, brazing, heat treatment, and vacuum tube manufacturing.

Sawing Machine for Metals and Plastics

A new metal sawing machine announced by the *Cochrane-Bly Co.*, 11 St. James St., Rochester, N. Y., is applicable for cutting ferrous and nonferrous metals and also plastics up to 2 in. in dia. Larger sizes and capacities for special stock sizes and production needs and either automatic, semi-

A metal sawing machine comes in a variety of sizes.

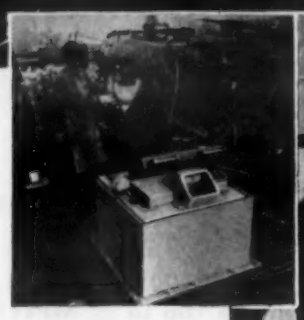
automatic and hand operated models are available.

Some of the general specifications are:

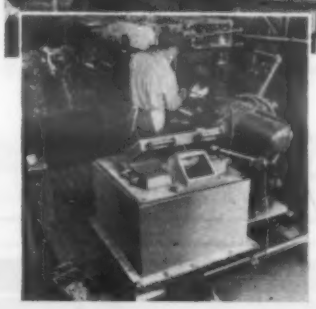
Blade diameter	—	12 in.
Carriage travel	—	2½ in.
Capacity of vise	—	2 by 2 in.
Blade speed	—	Supplied to suit specific material
Motors	—	2 to 5 hp., depending on size

AJAX
TAMA-WYATT

IS MAKING NEWS BY ELECTRIFYING THE ALUMINUM ALLOY INDUSTRY



Views showing AJAX furnaces in operation at the Johnson Motors Division of the Outboard Marine & Manufacturing Co., Waukegan, Ill.



Photos Courtesy "Electrified Industry"

A large number of aluminum die castings are used in the manufacture of outboard motors. The more precisely these castings meet standard specifications for size, strength, quality and weight, the lower are overall production costs. AJAX Tama-Wyatt Induction Melting Furnaces contribute to the uniformly high efficiency of the Johnson plant and to the quality of their castings.

ACCURATE CONTROL FOR MASS PRODUCTION OF PRECISION PARTS IN AJAX ELECTRIC MELTING FURNACES

THE aluminum foundry has long needed an induction furnace suited to continuous high output. AJAX Tama-Wyatt Induction Melting Furnaces are being extensively installed by nationally known manufacturers like the Johnson Motors Division of the Outboard Marine & Manufacturing Co., in their new all-electric die casting plant at Waukegan, Ill., U.S.A.

For the first time time in industrial history this die casting plant is using electric furnaces exclusively to melt and hold metal to be processed in die casting machines.

AJAX ENGINEERING CORPORATION
Trenton 7, New Jersey

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies
AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting

Handle Scrap *FASTER - EASIER*

This Burro is handling scrap faster and easier because it moved itself and several cars to the job quickly —and started work without delay. Burros equipped with magnet, clamshell bucket, dragline bucket, tongs or hook are saving time and money on many jobs in every type of industry. Their powerful draw bar pull (7500 lbs.) and fast travel speeds (up to 22 MPH) make them efficient switch engines too—you can spot cars where and when you want them at a moment's notice. There's no waiting time when a Burro is on your *track*.

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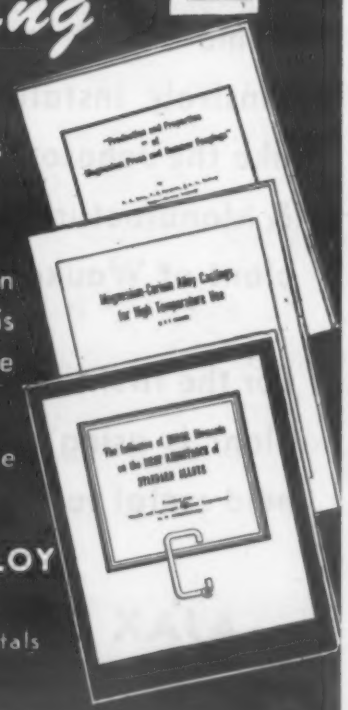
"The Influence of Minor Elements on Heat Resistance of Standard Alloys" is the latest addition to the Cerium File Folder. It is available on request.

Is your name filed with us to receive new publications, as issued?



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News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

G. Thomas Muehlenkamp, metallu gist, has joined the staff of Battell Memorial Institute, Columbus, to d research on the engineering properti of materials. A graduate of Not Dame University, previous connection have been with Wright Aeronautic Corp. and the University of Californi

Richard P. Harris, formerly assi tant to the factory manager, U. Rubber Co., Detroit, has been ma factory manager, Electroforming Dep that company. He was previously a sistant to the factory manager, Chanc Vought Div., United Aircraft Corp Stratford, Conn. He has had sever positions in metals fabrication and i industrial engineering.

Elmer Schneider has been elected a newly-created position with Wheelc Instruments Co., Chicago, called vi president and director of engineerin His duties will include inspection an approval of quality standards. *Josep A. Reinhardt* becomes plant manage and assumes responsibility for a manufacturing operations, joinin Wheelco after 25 years' experienc with General Time Instruments Corp Elgin Watch and Dole Valve com panies.

Waldemar Naujoks has been electe president, Bison Forge Co., Buffal where he has become associated a partner with *David L. George.* M Naujoks is an outstanding authority o forging practice, particularly in de sign and technique. He is author o "Forging Handbook" and prominen in technical societies. He was formerl chief engineer, Steel Improvement Forge Co., Cleveland.

E. F. Tibbets has become metallur gical engineer, the Lummus Co., Ne York, designer and constructor o petroleum refineries and chemica process plants. He was formerly assis tant materials engineer, Shipbuildin Div., Bethlehem Steel Co., Quincy Mass.

R. R. Donaldson has been made chie engineer, Hagan Corp., Pittsburgh

News of...

ENGINEERS COMPANIES SOCIETIES

ker of combustion controls. He has veloped new control mechanisms and ir application to steel and other lustries.

J. C. Peirce has joined Pangborn orp., Hagerstown, Md., for develop- nt of sand blast and core knock-out stallations. Previously he was sales nager and chief foundry engineer, dro Blast Corp., Chicago. He has en connected with several foundry mpanies.

Vere B. Browne is now research nsultant, Heppenstall Co., Pittsburgh d Bridgeport, Conn. He has been as- iated with research and develop- nt of high alloy steels since 1909 en he was named chief chemist, legheny Steel Co. *Lloyd R. Cooper,* ing director of Heppenstall research, now in charge of the newly-opened search laboratory.

Walter A. Jayme has been made as- tant general superintendent, Na- nal Tube Co. at Gary, Ind. Soon ter joining Carnegie-Illinois Steel orp. he managed the metallurgical partment's alloy bureau. In 1945 he rected research for the National Tube o.'s war rocket program. He was aduated from Massachusetts Tech in ining and metallurgical engineering.

William H. Pugsley has been made ce president in charge of field re- arch, Hays Corp., Michigan City, d., maker of industrial combustion struments and control.

A. J. Fischer has been made mana- r, Carbide & Cast Alloy Div., Jessop eel Co., Washington, Pa., having en with the carbide industry for 12 rs, serving Union Wire Die Co., harles Hardy Co., American Cutting lloy Co. and Firth-Sterling Steel Co.

Eugene Mittelmann, consulting en- neer and physicist, has opened of- es and laboratory at 549 W. Wash- gton Blvd., Chicago 6, practicing in gh frequency heating, industrial ectronics, applied physics, etc.

Engineers

Newcomers to the staff of Battelle emorial Institute are the following: *aniel J. Maykuth,* metallurgical en- neer, assigned to nonferrous metal- rgy; *Robert A. Miller,* formerly met- llurgist with Inland Steel Co., who ill serve in the division of industrial

"When I worked in Dayton, we used ***Strenes Metal*** cast dies for refrigerator tops and doors. Saved a lot of time and cost on tooling up. And we got longer runs between redressings."

That's the way the good word about ***Strenes Metal*** cast dies has spread from shop to shop. A number of instances are shown in our picture book titled "*Strenes Metal Castings.*" A copy is yours for the asking. Write us now while you're thinking about it.

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DRAWING AND FORMING DIES

THE ADVANCE FOUNDRY COMPANY
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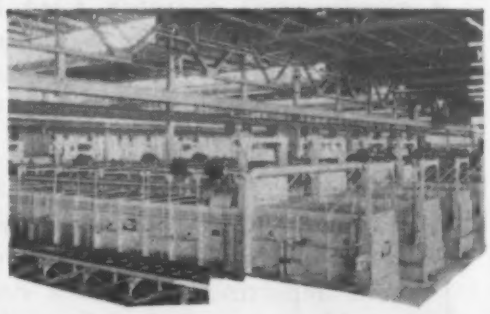

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3. Carburizing *time is reduced* by activated gas.
4. Production results are *dependably duplicated.*
5. Process provides either batch; or continuous with heating, carburizing, diffusing, atmosphere cooling, or oil quenching—*all automatic.*

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WIRE PRODUCTS SINCE–1880

News of...

ENGINEERS COMPANIES SOCIETIES

physics; *Earl R. Olson,* chemical engineer, who will do research on the engineering properties of materials.

Richard K. Lee has been made technical director, Alloy Rods Co., York, Pa., having had over ten years' experience in the welding field, for five years being connected with the Steel & Tube Div., Timken Roller Bearing Co.

A. H. Milnes is now chief engineer, Steel Improvement & Forge Co., Cleveland. Previously he was metallurgist in England with aircraft manufacturing companies.

H. Dann, formerly with U. S. Bronze Powder Works, Inc., where he did research and development on new production methods in the bronze powders field, has become production manager for Atlantic Powdered Metals, Inc., New York.

G. Taylor Stanton recently became manager of engineering, Holtzer-Cabot Div., maker of electrical motors, having been chief engineer, TelAutograph Corp. He designed the sound system in the General Motors Futurama at the New York World's Fair.

L. C. Grimshaw has been named metallurgical engineer, Clad Products Div., Jessop Steel Co., Washington, Pa. Other company connections have been with Latrobe Electric Steel Co. and Allegheny-Ludlum Steel Co.

Donald E. Williamson, for many years with the Physicists Research Co., has joined the research and development department of Baird Associates, Inc. More recently he was with Lincoln Park Industries, Inc., in developments related to precision gaging.

Frank D. Hazen, who has written many technical papers and made many contributions to the furnace industry, has been made vice president and general manager of the industrial department of American Arch Co., Inc.

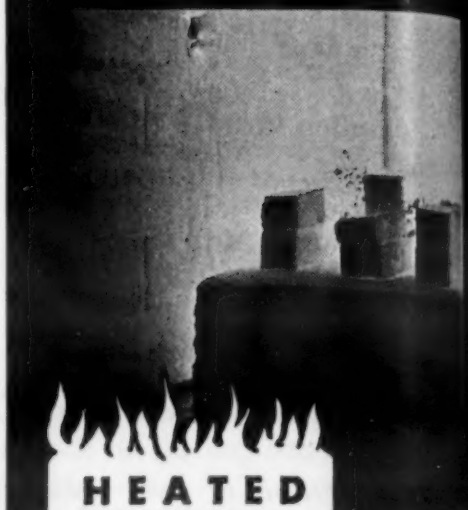
Howard J. Smith has joined the research staff of Titanium Alloy Mfg. Co. as a senior chemist, having served as chief chemist, Joliet Chemicals, Inc., Joliet, Ill.

Ellsworth T. Candee has been made director of research and development, Lea Mfg. Co., Waterbury, Conn., maker of polishing and buffing compounds. He was formerly with the American Metal Hose Branch, American Brass Co.

Demonstrating

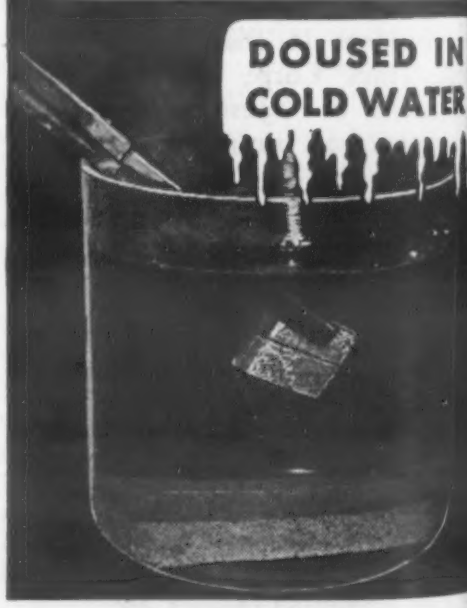
BRICKSEAL

REFRACTORY COATING



Brickseal provides a crackproof, vitrified armor for furnace linings. The small firebricks shown in the furnace were bonded and painted with Brickseal and heated to 2250°. Directly from the furnace they were plunged into cold water as shown below—a test for *any* material subject to expansion and contraction.

Brickseal is *semi-plastic when hot,* yet *hard and tough when cold.* Brickseal is made in grades suitable to heats ranging from 1400° to more than 3000°. It will make any furnace last longer by giving new life to your refractories. Write or call local dealer for a demonstration.



BRICKSEAL

REFRACTORY COATING

5800 S. Hoover St., Los Angeles, C

1029 Clinton St., Hoboken, N.

News of...

ENGINEERS
COMPANIES
SOCIETIES

Companies

The *Scovill Mfg. Co.*, Waterbury, nn., has awarded a $2,000,000 con- uction contract for a building hous- g an addition to its cold rolling mill copper alloys in sheet and strip m. Construction consists of an ad- ion to a building completed in 1916.

Lindberg Engineering Co., Chicago, ker of heat treat furnaces and elec- cal equipment, and *Fisher Furnace* ., same city, maker of nonferrous lting furnaces, refractories and owers, have united their organiza- ns. The Fisher organization will be own as *Fisher Furnace Div., Lind- rg Engineering Co.*

The *Connecticut Precision Casting* . has been formed by C. T. Finn and T. Butterworth, Jr., New Canaan, onn. They will use the "lost wax" rocess.

The *Bullard Co.*, Bridgeport 2, onn., has made up a 27-min., 16-mm. ound film covering their Man-au-Trol ertical turret lathe, with another 14- in. film on their spacer.

The *Al-Fin Corp.*, subsidiary of *Fair- hild Engine & Airplane Corp.*, has oved from Hollis to Farmingdale, ong Island, offices and foundry being the plant of the *Ranger Aircraft ngines Div., Fairchild.* The process nsists of chemically bonding alumi- um and its base alloys to steel.

Eastern Industries, Inc., has pur- ased the buildings, machinery and oduction rights of the *McIntyre Co.*, ewton, Mass., maker of precision umps and fluid motors. Eastern mix- g equipment, laboratory stirrers, heat issipating units for electronic appli- ations, and precision temperature egulators will be made at Eastern's orwalk, Conn., plant.

Complete renovation of the gray on foundry of *Babcock & Wilcox Co.* t Barberton, Ohio, at a cost of over 500,000 is being planned. The largest xpenditure for machinery will be for complete sand conditioning system.

The *Rare Metal Products Co.* has nnounced removal of offices, chemical lant and laboratories from Belleville, N. J., to Atglen, Pa.

Selenium Corp. of America, affiliate of *Vickers, Inc.*, maker of selenium ower and instrument rectifiers and elf-generating photo-electric cells, now

the use of AJAX PHOSPHOR-COPPER

15 STANDARD ALLOYS BY AJAX

Ajax Tombasil
Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

Send for booklet "Ingot Metals of Today"

NOTE: * "Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Non-ferrous Ingot Metals of Today." Write for both. They are free.

Successful foundrymen deoxidize or "clean up" molten metal by a scientific method worth using as indicated:

They use phosphorus . . . expertly . . . in the form of "Ajax Phosphor Copper" . . . added as the crucible is removed from the furnace . . . for virtually all brass and bronze alloys.

In notched waffle sections, or in shot form, Ajax 15% P-Cu does its work at .01% (1 oz. per 100 lbs.). Introduced, and having time to react when stirred with a whirling motion of the skimmer, it causes oxides to rise for effective removal by skimming from the surface. It is best to avoid phosphorus build-up from back stock.*

If you use phosphorus these days, use Ajax phosphor Copper (useful also in producing your phosphor bronze).

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AJAX ELECTRIC CO. ● AJAX ELECTROTHERMIC CORP. ● AJAX ELECTRIC FURNACE CO. ● AJAX ENGINEERING CO.

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For the first time, a complete catalog designed to give the manufacturer of precision small parts, the full picture of the "Lost Wax" process.

★ The story of "Lost Wax"
★ How to set up shop
★ How the process works
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News of...

ENGINEERS COMPANIES SOCIETIES

occupies a new modern structure at 2160 E. Imperial Highway, El Segundo, Calif.

N. Ransohoff, Inc., Cincinnati, maker of washing machines and equipment for surface treatment of metals, has bought another plant at 16 E. 72nd St., that city.

International Nickel Co. announced an extension of its fellowship awards in Canada, Great Britain and the United States, as part of a broadened program of cooperation with universities and colleges in the field of technical education. In this country six two-year fellowships will be awarded bi-annually for 12 years and for study of nickel, copper and the platinum metals.

An order for nearly $6,000,000 worth of electrical steel mill equipment, the largest single order of its kind ever placed, has been booked by *Westinghouse Electric Corp.* for the French firm of *Denain Anzin.*

A new firm of chemical, metallurgical and mechanical engineers has been formed by Dr. Chester L. Knowles, Otto R. Kuster and Robert C. Ried. It will be known as *Knowles Associates,* 19 Rector St., New York 6.

The *Nash-Kelvinator Corp.* has awarded to the Bjorksten Research Laboratories, Chicago, a research contract relating to plastic fabrication, the second substantial contract so awarded.

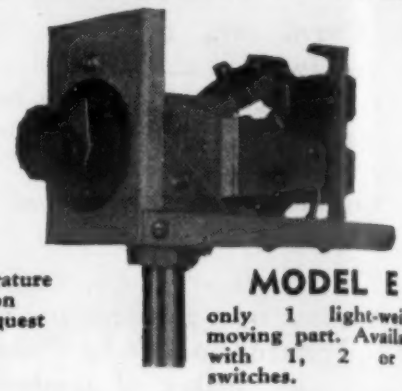
Societies

Dr. George R. Harrison, dean of the School of Science, Massachusetts Institute of Technology, has been elected chairman of the *American Institute of Physics.* He is author of the popular book, "Atoms in Action." The reorganized institute is made up of the following societies: *American Physical Society, Optical Society of America, Acoustical Society of America, Society of Rheology,* the *American Association of Physics Teachers,* and about 9000 individual members.

The *National Assn. of Corrosion Engineers* has named the first two recipients of newly established awards: Dr. Willis R. Whitney and Dr. Frank N. Speller. The former established the electrochemical theory in corrosion.

BURLING TEMPERATURE LIMIT SWITCHES

USE NO LIQUIDS . . . NO GAS



Literature on Request

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only 1 light-weight moving part. Available with 1, 2 or 3 switches.

As a 3 switch model, Burling Model E recommended for use (a) where load divided into 3 parts, (b) where 1 switch used for controlling, one as a high lim one as a low limit, (c) to give definite st or position to a 3 or 4 position diaphrag motor, (d) to give 3 speed control variable speed motor.

- Accurate, Rugged, Dependable
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- Dial Pointer for easy setting
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- Snap-action Micro-Switch elimina contact troubles
- Increased Adjustable range to 700-100
- Dimensions—7¼" x 2¾" x 3½"

MODEL V-I

For lower temperature range from 0-300°F. Available for minimum of —100° to maximum of 600°F. Usual adjustable range 50-150°, operating differential may be as small as ±¼ or l large as ±5°. Adjustable by screw and dial inside case. (Sizes 2¾" diameter × 4¼" high)

MODEL D

Adjustable rang 200-500°F. Temperature rang 0-1400°F. For use where temperature must be changed to suit operating conditions. Turn outside knob to change temperature setting. (Sizes 5½ x 2¾ x 2¾").

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Harper

ELECTRIC FURNACES

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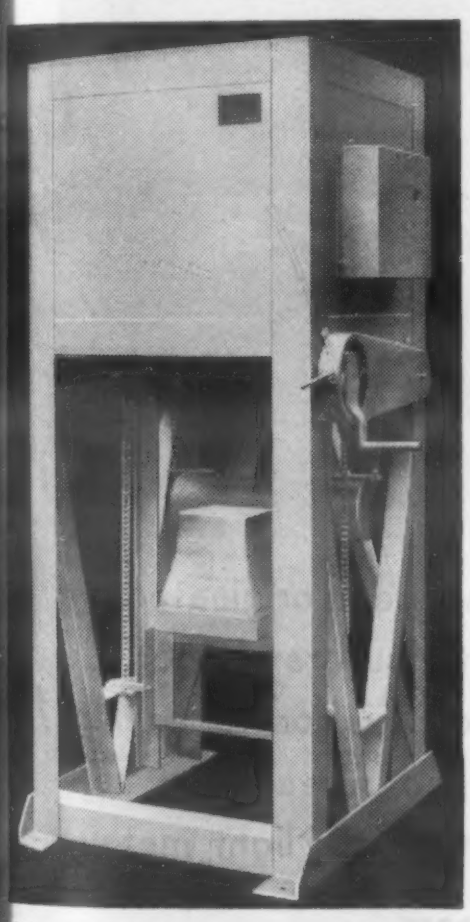
All Harper Furnaces are designed for convenience and safety. Heavy insulated doors, elevating hearth mechanism, continuous conveyor belts, standard, inverted and tilting designs contribute to better operation, easy handling of crucibles and materials.



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News of...

ENGINEERS COMPANIES SOCIETIES

Dr. Speller's award was for his application of fundamental studies to practical engineering problems.

W. B. Peirce, vice president in charge of research at the Flannery Bolt Co., Bridgeville, Pa., has been elected president of the *American Society of Tool Engineers*. At a recent convention the new president declared war on the antiquated English inch system of measurement, stating that the simpler metric system is necessary "if we are to keep pace with the rest of the mass producing countries of the world."

The *American Society of Body Engineers* will hold its second annual technical convention at the Rockham Memorial Bldg., Detroit, Nov. 5 to 7. Speakers at the eight general sessions will cover new trends in styling, production engineering, small cars, seating comfort, truck bodies, buses and coaches, materials in body construction and passenger car body engineering. Society membership now totals 200.

The *Magnesium Assn.* has honored Edward S. Christiansen, its founder, with a magnesium plaque for his "vision and incessant energy to consolidate, perpetuate and expand the progress made in the production and fabrication of magnesium during World War II."

Meetings and Expositions

INSTITUTE OF THE AERONAUTICAL SCIENCES, summer meeting. Los Angeles, Calif. Aug. 7-8, 1947.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, bi-monthly meeting. San Diego, Calif. Aug. 26-29, 1947.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Salt Lake City, Utah. Sept. 1-4, 1947.

INSTRUMENT SOCIETY OF AMERICA, conference and exhibit. Chicago, Ill. Sept. 8-12, 1947.

PORCELAIN ENAMEL INSTITUTE, annual forum. Columbus, Ohio. Sept. 10-12, 1947.

NATIONAL PETROLEUM ASSOCIATION, annual meeting. Atlantic City, N. J. Sept. 17-19, 1947.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION, Machine Tool Show. Chicago, Ill. Sept. 17-26, 1947.

ASSOCIATION OF IRON & STEEL ENGINEERS, fall meeting. Pittsburgh, Pa. Sept. 22-25, 1947.

Preparing Aluminum Surfaces For Perfect Paint Adhesion

IF you are engaged in the production of such aluminum articles as canoes, furniture, lawn mowers and the like you will want to give your product a paint finish with stimulating sales-appeal. More than that you will want a finish that will "stand the gaff".

You will be on the right road to meeting these two important specifications if you condition your aluminum parts with

Oakite Compound No. 36

Applied manually or by still-tank this mildly acidic compound produces a microscopic surface etch and develops a thin phosphate film to condition surfaces for tenacious paint adhesion and to localize corrosion when damage occurs.

Oakite Compound No. 36 exerts mild detergent action. Used on lightly soiled parts, Oakite Compound No. 36 will eliminate initial degreasing operations to save production time and reduce per-unit production costs.

In-plant test runs of Oakite Compound No. 36 under the direction of an Oakite Technical Service Representative invited. Literature freely available on letterhead request. Ask for Service Report #A-5883.

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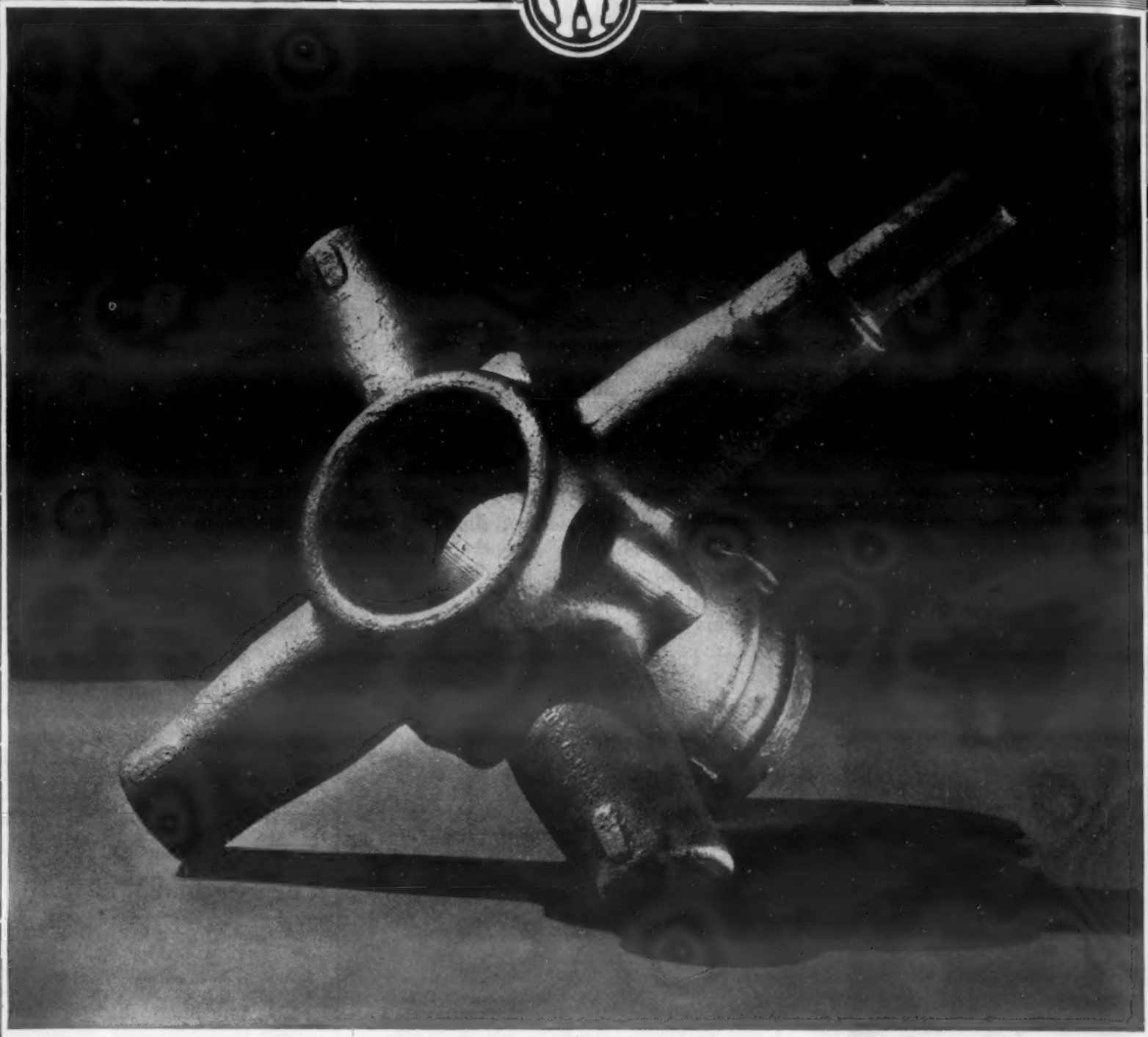

Many forging designs in steel, aluminum and magnesium have been originated by Wyman-Gordon. Typical of the many intricate forgings is this four-way spider.... Every Wyman-Gordon forging is under strict, constant control by laboratories that through the years have contributed much to investigation and research of new forging techniques and of new alloys of steel and the non-ferrous light metals.

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The Last WORD

by T. C. DU MOND

Glamour in Picket Lines

If the truth were only known, the reason why a truce was signed by the steel union and producers might be due to an inferiority complex on the part of the unions. During the last few months glamour has been injected into picket lines all over. First there were the telephone "hello" girls; next feminine dance instructors with their conga-picket lines outside Arthur Murray's, and more recently cartoonists on strike against the producers of Terrytoon movie cartoons. In the latter case highly original and pointed cartoons were carried by the pickets, fore and aft, to amuse as well as propagandize passers-by. There's not much glamour in a husky mill hand parading in his overalls.

Is it a Disk or a Disc?

We are about to launch a one-man campaign against misusers of the word "disk." For some reason this poor word is neglected all too often and its place taken by its first cousin "disc." The country is now overwhelmed with a rush of "disc" jockeys, and in a recent new product announcement the word was used by an apparently neutral author, for he spelled it both ways in successive paragraphs. We're sure that if we and Webster threw our weight about enough, we can convince people that "disc" is a zoological word meaning "any of various structures likened to a disk."

Sweet Are the Uses of Adversity

The housewives of the nation owe a debt of gratitude—at least a moderate sized one—to the Koppers Company Piston Ring Div. Why? Well, during the sugar shortage days there arose a little concern, since sugar was the only reducing agent used in solutions for porous chromium plating of piston rings. So, the boys diligently searched for a substitute and tried many things until they found that maltose syrup did the trick. The maltose reaction was somewhat different but it had the final desired result, thus releasing considerable quantities of sugar for other uses. Come to think of it, here's our thanks also. Coffee without sugar is not so—should we say—hot.

Our Insulting Nonsubscribers

It must have been a warm day like this when our circulation manager wrote a subscription letter in which he teed off with a quotation to the effect that "The best study of man is man" and not too certainly credited it to Bill Shakespeare. Back came one of the letters—without the important filled-in subscription form—an arrow pointing to the quotation and a very few well chosen words. The words: "Pope you dope."

Many a Truth is Spoke in Jest

Early in June a number of editors journeyed down to Kure Beach, N. C. to visit the corrosion test station there. International Nickel's Frank La Que acted as host and put us at ease immediately with a welcome address that was remarkable, to say the least. Although the words of welcome were uttered in a spirit of fun we had the uncomfortable feeling that they might contain a germ of the true feeling of industrious engineers. Reduced to their bare essence, the greeting went something like this: "Come on in if you have to, but if you weren't bothering me I could get a whale of a lot of work done." We got even though and deluged Frank and the other technicians there with a flood of poetry unlike any they ever encountered before—or probably will ever meet again.

Problems with the Atom

Don't put off buying that new car in the hopes that one of next year's models will be built around an atomic power plant. In the first place, our present knowledge of the shielding power of materials against radioactive substances would indicate that a piece of uranium the size of a golf ball would require 50 tons of shielding material. Of course the energy resulting from the fission of that amount of uranium would be sufficient to satisfy the needs of Mr. Average Motorist for something like 200 years.

One important point brought out along with the above at the Chicago A.S.M.E. meeting is that henceforth, at least in dealing with atomic energy, we are going to require a purity in materials which never before was dreamed of commercially. For instance, carbon, an important material in the atomic scheme of things, would be almost useless if it contained only 10 parts per million of boron as an impurity.

One and One Equals 200

One and one equals 200, when one one is a refrigerator and one one is a lawn mower. The 200 is the amount of steel required for one each of these products. Figures compiled by the American Iron & Steel Institute show that 171.66 lb. of sheet and strip steel is needed to make one refrigerator and 27.60 lb. of sheet, strip, bar, wire and tube goes into a lawn mower. The magnesium people might dispute that last figure, in view of the fact that magnesium, like June, is busting out all over, in lawn mowers. We don't want to start an argument, but we were just wondering.

FINIS